MECHANICAL ENGINEERING

· JULY 1950 ·

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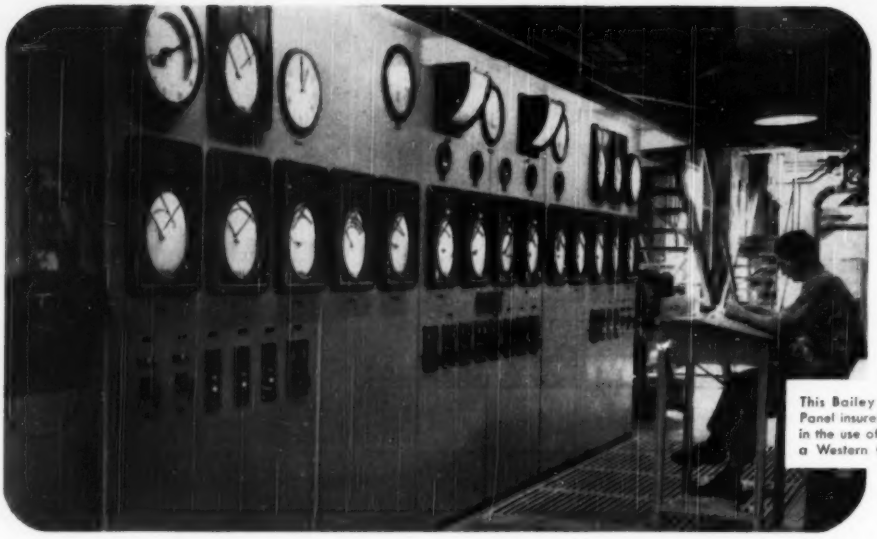

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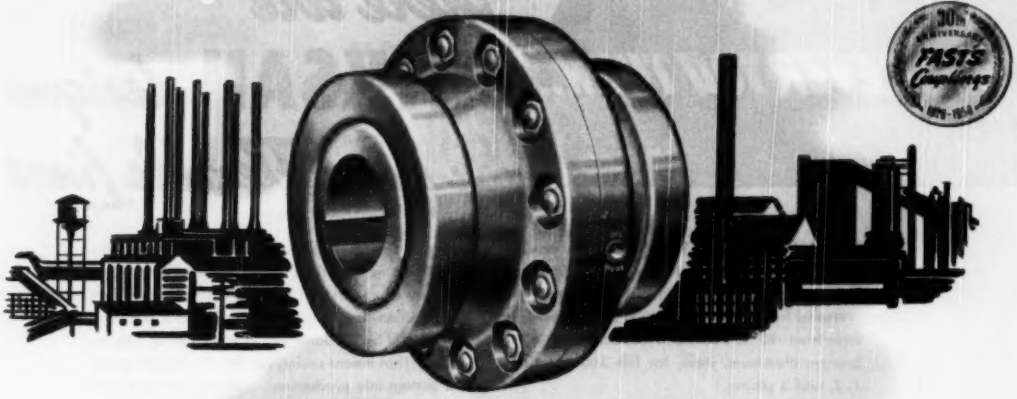

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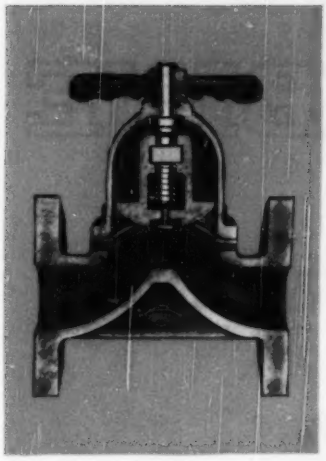

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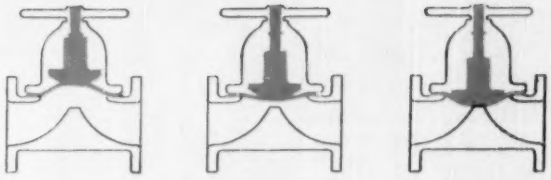

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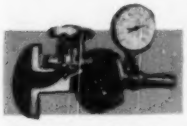

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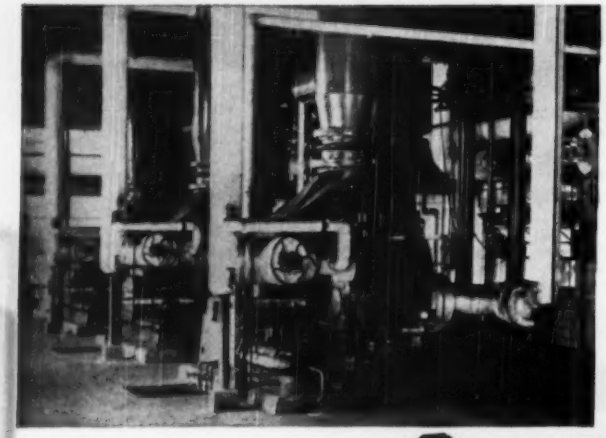
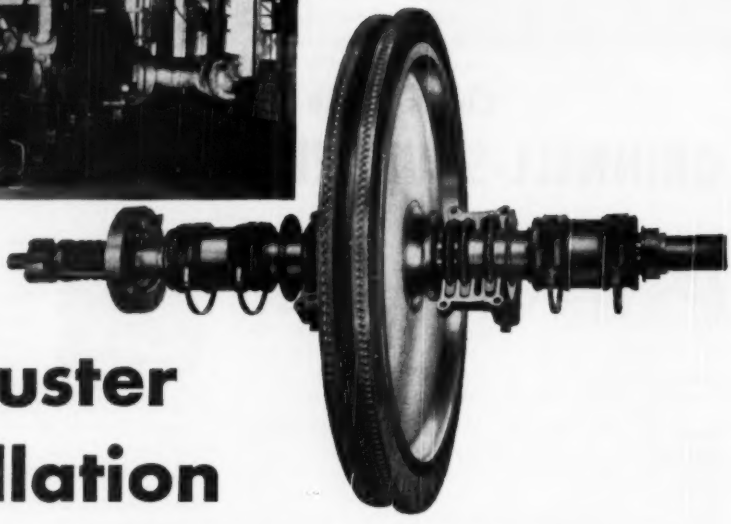


The rotor shown below has special stainless steel blades with heavy sections and sharp edges firmly held in a dovetailed groove in the wheel rim.



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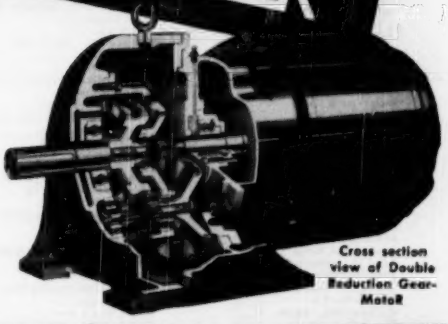
GearMotoR conforms to the recommended standards of the American Gear Manufacturers Association and the National Electrical Manufacturers Association.

Write for a copy of the 42 page illustrated GearMotoR catalog. Please use your Business Letterhead when writing.



Cross section view of Double Reduction GearMotoR

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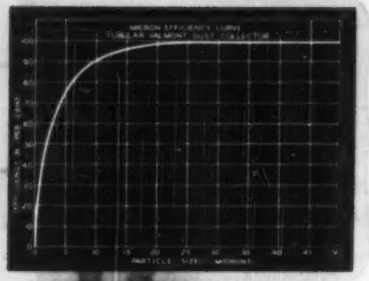
THE VALMONT TYPE S COLLECTOR

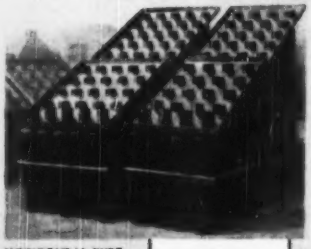
CATALOG DIGEST

The following information is taken from the New Bulletin on P-D Valmont Type S Collector. For Complete Bulletin containing dimension tables, sizes, nomographs and suggested installation plans, write our Project and Sales Engineers.

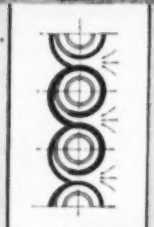


P-D EFFICIENCY CURVE

VALMONT TYPE S TUBES SHOWING FLOW OF GASES AND INLET



HORIZONTAL TYPE TUBE SHEET SECTIONS KNOWN AS "UNI-BLOCS"



METHOD OF NESTING TUBES—REDUCES TURBULENCE . . . SAVES SPACE

HIGH EFFICIENCY—The outstanding contribution to higher efficiency in the P-D Valmont Type S is the inlet slot design. A patented development of Prat-Daniel, this inlet is high and narrow, reducing the radial distance of dust-travel. To explain its effect on dust collection, we quote from Cyclone Dust Collector Design, by Melvin W. First, Paper No. 49-A-127, presented at the Annual Meeting of the American Society of Mechanical Engineers, Nov. 27—Dec. 2, 1949, page 14.

> "Entry width is an important variable in cyclone efficiency, as it controls the stream width. This, in turn, directly controls the radial distance particles must traverse to reach the cyclone wall and be separated by centrifugal force. The smaller the radial distance to be traversed, the lower the tangential velocity needed (less energy loss) and the smaller the particle that can be successfully separated for a given flow rate."

LONG LIFE—Extensive tests were made to determine the wear factor. All types of abrasive dusts were run at accelerated speeds, against various metals simultaneously and steel proved to be the most resistant to erosion.

Another long life factor is the lower velocity required due to the small tube diameter. It is a well-known fact that reduction of tube diameter produces higher centrifugal force. Thus, efficiencies are maintained at the lower load ranges.

MASS PRODUCTION METHODS—The P-D method of "uni-bloc" construction permits manufacture and assembly of sub-sections at the factory. These are shipped to the field and easily erected, either vertically or horizontally, to fit the layout. Savings in cost of erection are thus realized yet the collector is "tailor assembled" to fit the installation requirements.

SMALL SPACE FACTOR—Because of close nesting of tubes possible in P-D Valmont Type S Collectors, the space required for this apparatus is much less than conventional collectors. In many cases, P-D units have been fitted into spaces that could accommodate no other type.

The Thermix Corporation, our Sales and Project Engineers are specialists in the art of dust collection. Consult them about your dust problems.

Project and Sales Engineers

THE THERMIX CORPORATION

Greenwich, Conn.

(Offices in 28 Principal Cities)

Canadian Affiliates: T. C. CHOWN, Ltd.

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Designers and Manufacturers of Power Plant Equipment for Over 25 Years

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WHAT ALLIS-CHALMERS

4-Point Motor Protection

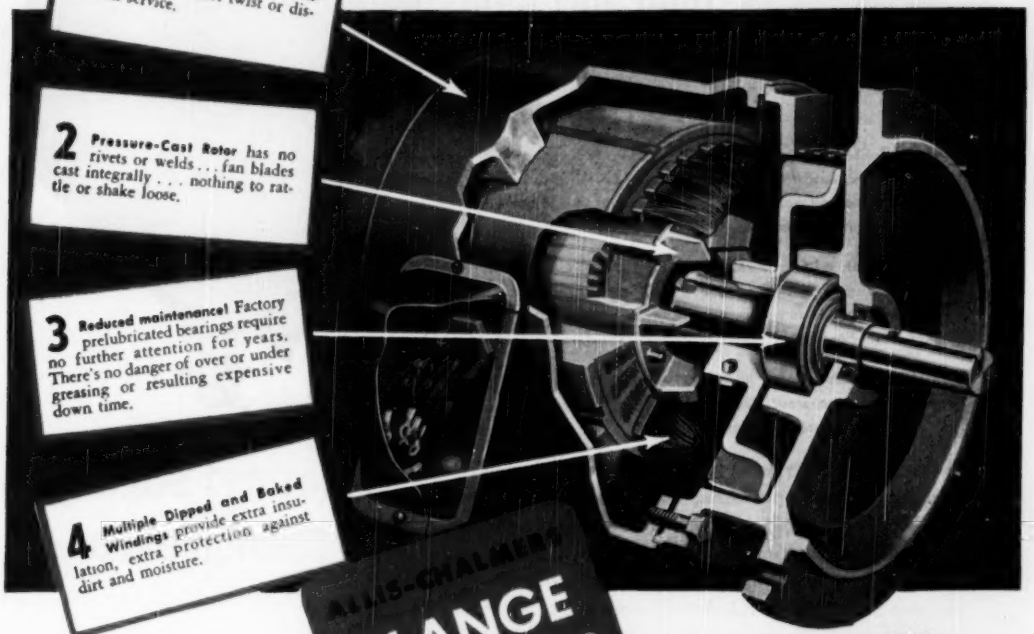
MEANS TO YOUR CUSTOMERS!

1 **Rigid Cast Iron Frame** completely surrounds and protects working parts . . . cannot twist or distort in service.

2 **Pressure-Cast Rotor** has no rivets or welds . . . fan blades cast integrally . . . nothing to rattle or shake loose.

3 **Reduced maintenance!** Factory prelubricated bearings require no further attention for years. There's no danger of over or under greasing or resulting expensive down time.

4 **Multiple Dipped and Baked Windings** provide extra insulation, extra protection against dirt and moisture.



ALLIS-CHALMERS FLANGE MOTORS

HERE'S THE MOTOR that's 4-point protected against high maintenance costs; designed with generous safety factor in every part . . . to give your product dependable, low-cost power for years to come!

CHOOSE FROM WIDE RANGE

C and D flanges and P bases in sizes from ½ to 150 hp in all NEMA ratings are available. Furnished with or without matching controls.

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More than 80 Allis-Chalmers Certified Service Shops are located in all major industrial areas. Your customers get fast, factory approved service, *no matter where they are located.*

For engineering information on the Allis-Chalmers Designer's motor line, check coupon at right. A-3090

Please send me:
- ☐ Flange Motor Specification Sheet 5157234
- ☐ Handy Guide for Electric Motors Bulletin 5186052
- ☐ General Purpose Motor Controls Bulletin 1487132

A-3090

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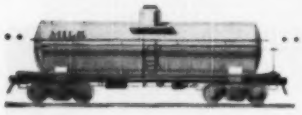
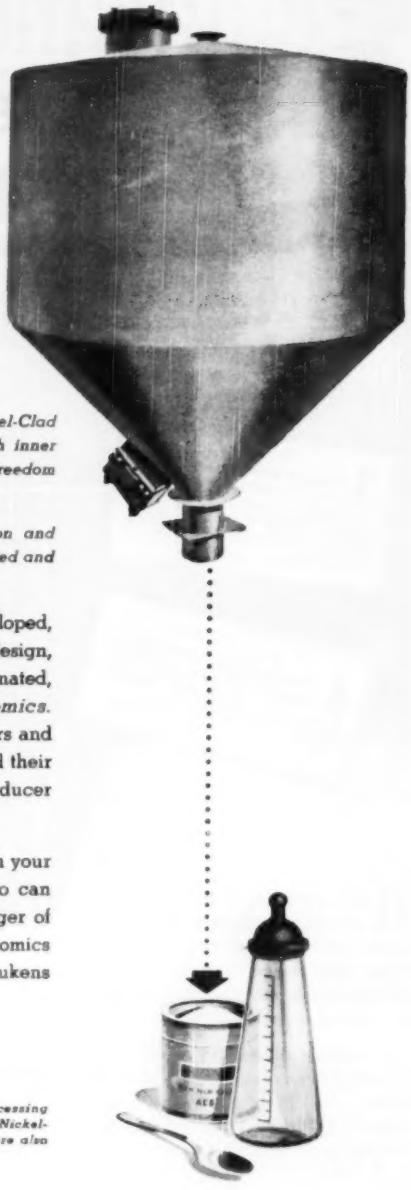
ONE OF A SERIES DEMONSTRATING APPLIED LUKENOMICS

How to Keep a Powdered Food Product From "Packing"...





EXAMPLE—*Economical, efficient handling in packaging a powdered, modified milk preparation to avoid product contamination and powder "packing" at M & R Dietetic Laboratories, Columbus, Ohio.*

DESIGN—*Tank with free-flowing contours built of Lukens Nickel-Clad Steel and equipped with powerful electric vibrators. Smooth inner nickel surface to insure protection of product purity and aid freedom of flow. Steel backing to give required strength and rigidity.*

RESULT—*Powder flows steadily to conveyor-packer, supervision and maintenance greatly reduced, washing out with water simplified and high purity easily maintained.*

These benefits are typical of results achieved with newly developed, more efficient food processing equipment. And wherever design, fabrication and materials selection must be critically coordinated, you will find the economical answer in applied *Lukenomics*. Lukenomics combines the experience of designers, engineers and equipment builders with Lukens' knowledge of materials and their application gained over 140 years as the world's leading producer of specialty steel plates, heads and steel plate shapes.

It's sound investment insurance to put Lukenomics to work on your equipment problems. There are progressive fabricators who can do this for you. Get in touch with them or write our Manager of Marketing Service, stating your problem. There's a Lukenomics team ready to go to work on it. Lukens Steel Company, 402 Lukens Building, Coatesville, Pennsylvania.

Glascote Products, Inc. fabricated the above processing tank for M & R Dietetic Laboratories using Lukens Nickel-Clad Steel. Lukens Flanged and Dished Heads were also used in the equipment.

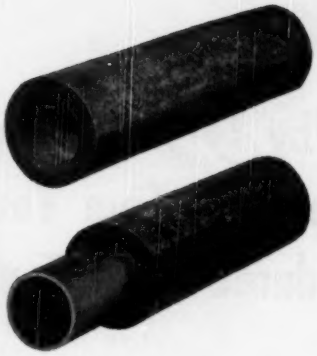
LUKENS

LUKENS STEEL COMPANY

BETTER PRODUCTS FOR BETTER EQUIPMENT

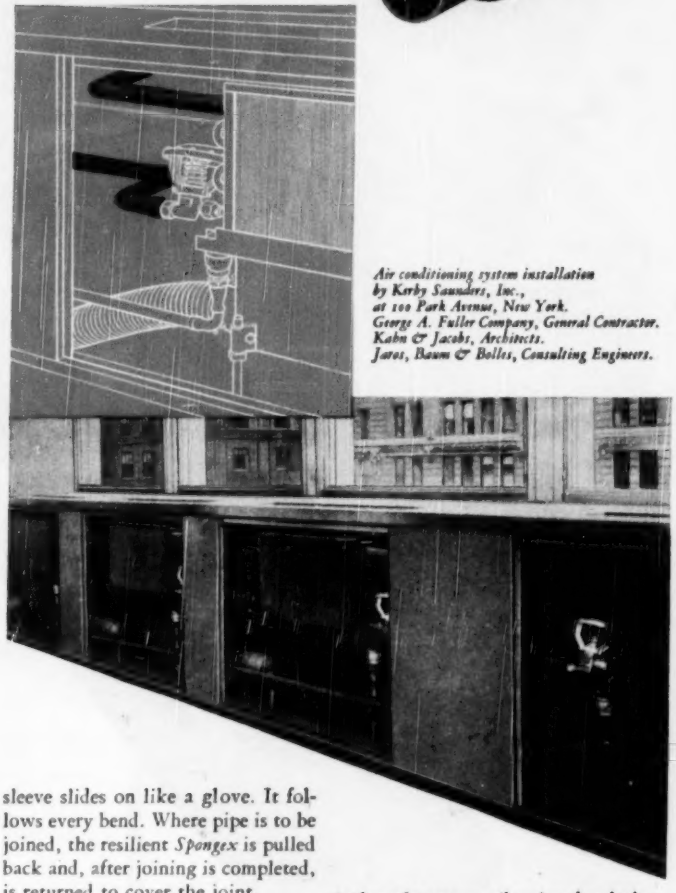
to an imaginative engineer...

this basic *Spongex*® form



yielded this idea

to become this application



Air conditioning system installation by Kerby Saunders, Inc., at 100 Park Avenue, New York. George A. Fuller Company, General Contractor. Kahn & Jacobs, Architects. Jaros, Baum & Bolles, Consulting Engineers.

in this climate control development

Cellular rubber does not become a "product" until you make it one in *your* application of its known qualities as insulation against shock, vibration, sound and air and temperature transmission. Thus, one of many basic forms of *Spongex* cellular rubber becomes a covering for copper tubing in the application made by Kerby Saunders, Inc., New York, mechanical contractors.

With *Spongex*, they overcome condensation and provide insulation in air conditioning unit feed and return lines. And they do so with the least expenditure of costly time and effort. No adhesives are needed. The simple sleeve slides on like a glove. It follows every bend. Where pipe is to be joined, the resilient *Spongex* is pulled back and, after joining is completed, is returned to cover the joint.

In every industry there exist problems that *Spongex* cellular rubber may solve. Think about it. If your thoughts are on vibration, insulation, cushioning, gasketing, sealing or sound damping, we can be your greatest help.

THE SPONGE RUBBER PRODUCTS COMPANY

301 Derby Place, Shelton, Conn.

Why "Buffalo" Water-Cooled Bearings Give You Better Induced Draft Fan Service

Close-up Showing Details of Self Aligning Water Cooled Bearing and Pedestal

You get longer and more trouble-free service when you specify "Buffalo" Induced Draft Fans. WRITE FOR BULLETIN 3750 for all the facts on the complete "Buffalo" line of draft fans.

"Buffalo" FIRST FOR FANS

BUFFALO FORGE COMPANY

148 MORTIMER ST. BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont., Branch Offices in all Principal Cities

VENTILATING FORCED DRAFT | AIR WASHING COOLING | AIR TEMPERING HEATING | INDUCED DRAFT EXHAUSTING PRESSURE BLOWING

WICKES TYPE A

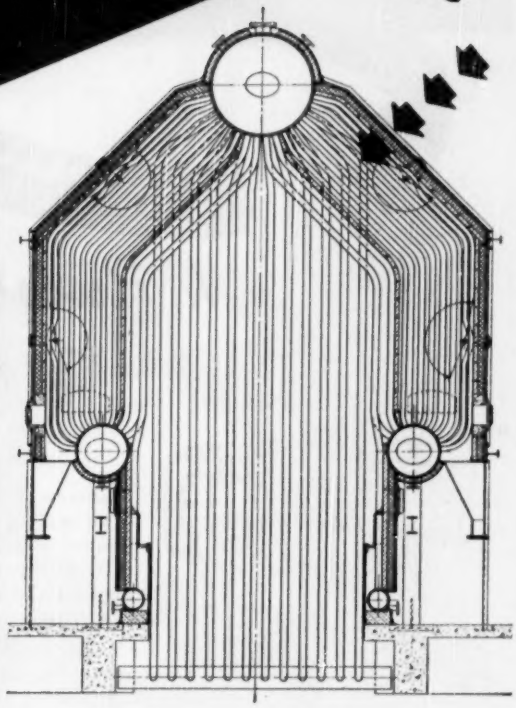
Three outstanding construction and design advantages make the Wickes Type-A Water Tube Boiler the most efficient of its type.

Wickes units have almost twice the black surface common to this class of boiler . . . this increases efficiency through greater heat absorption, permits carrying a higher CO_2.

Wickes steam generators draw the combustion gases through well-insulated passages across rows of staggered tubes . . . speeding optimum convection heat pickup, maintaining high operating efficiency.

Wickes Boilers assure fast, smooth water circulation through two simple U-tubes—higher absorption with no danger of clogging . . . proper baffling for unobstructed flow.

It will pay you to take advantage of Wickes' expert consultation before you buy a boiler. Wickes Steam Generators are sold and serviced the world over. Write today for complete catalog.



Wickes Type-A Water Tube Boiler with 450 HP and 350 lbs. design pressure.

THE WICKES BOILER COMPANY • SAGINAW, MICHIGAN

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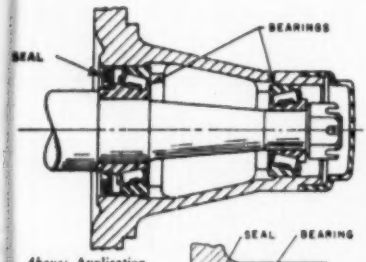
DIVISION OF THE WICKES CORPORATION • RECOGNIZED QUALITY SINCE 1854

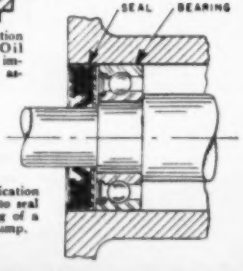
A 2-FISTED OIL SEAL

PATENTED

1. Resists Oil and Heat
2. Resists Wear —

because of "live" spring action





Above: Application of KLOZURE Oil Seal on a farm implement wheel assembly.

Right: Application of KLOZURE to seal a ball bearing of a centrifugal pump.

GARLOCK KLOZURE Oil Seals deliver the "one-two" punch. The sealing element is made of a special Garlock compound which resists oil and is unaffected by heat up to 250° F. The flexible and sensitive "live" action of the spring against the resilient sealing element in Models 53 and 63 KLOZURES reduces wear and friction to a minimum.

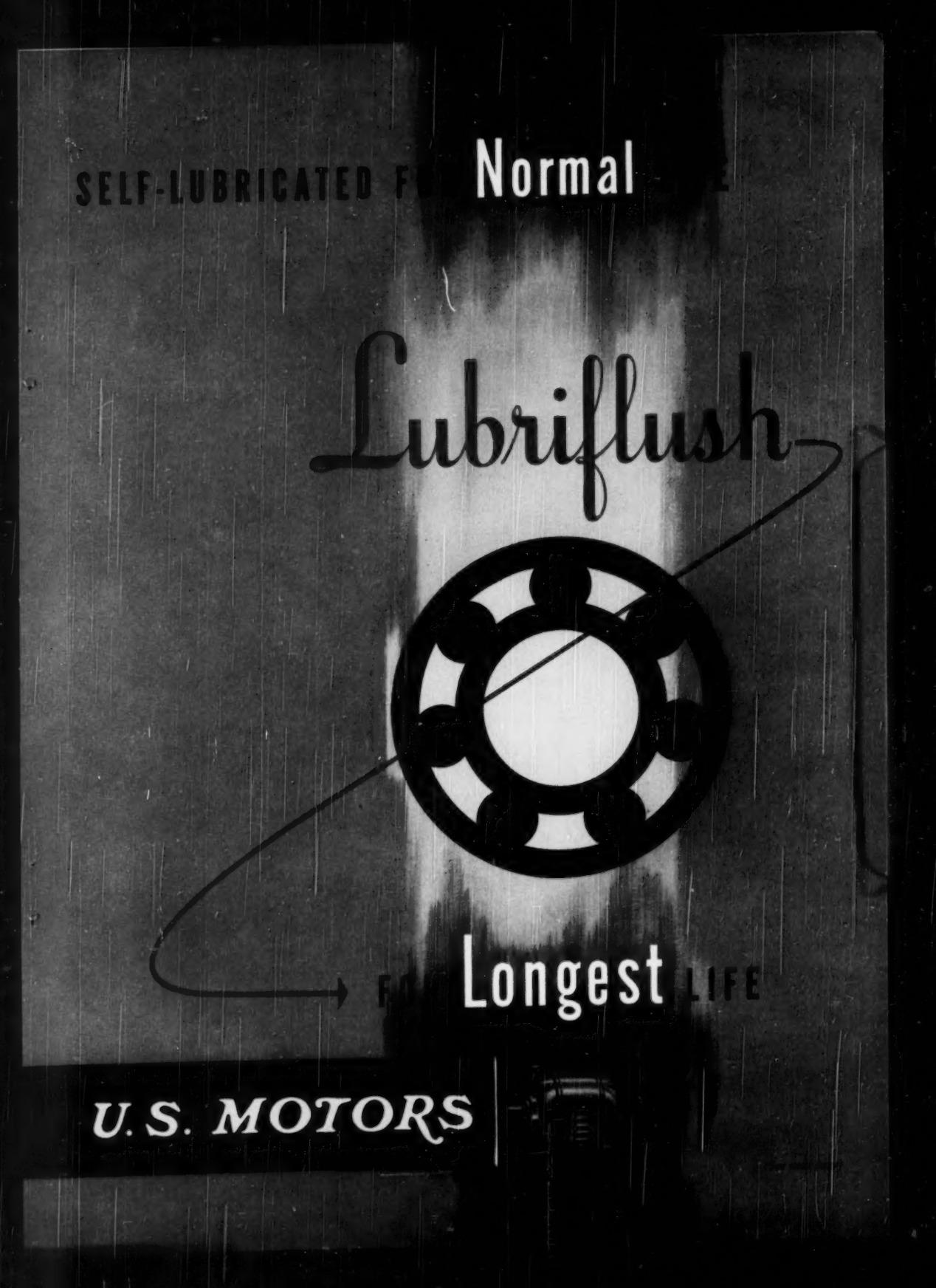
Model 53 KLOZURE (illustrated above) is produced in a range of sizes for 3" to 10" shafts. Model 63 KLOZURES, employing the same engineering principles but differing in details of design, are made in a range of sizes from ¼" to and including 3" shafts. Write for KLOZURE catalog.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK *Klozure** OIL SEAL

*REG. U. S. PAT. OFF.


SELF-LUBRICATED F
Normal
Lubriflush
F
Longest
LIFE
U.S. MOTORS

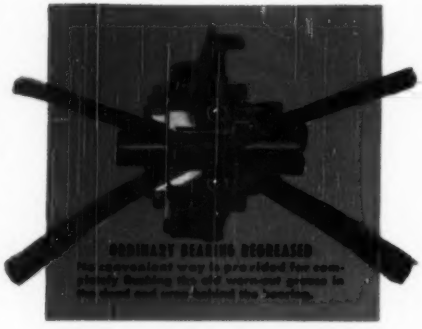
U. S. MOTORS

SELF-LUBRICATED *for normal life*

plus LUBRIFLUSH *for longest life*

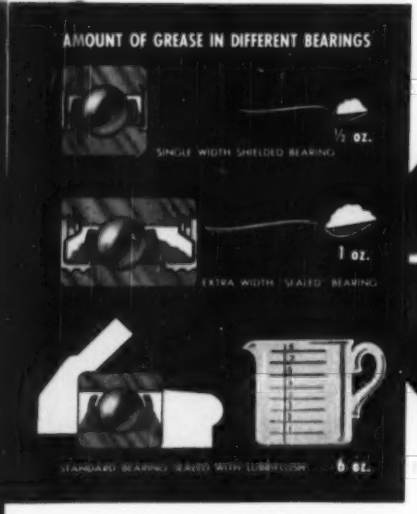
Far Superior to Ordinary Lubrication

When bearing grease fails, any bearing can fail. Life of a bearing depends upon the effectiveness of the lubricant. As long as the proper grease is uncontaminated by acid, dirt, dust and flakings, bearings are long lasting. But no pre-lubricated bearing is 100% sealed, and the lubricant will deteriorate. Bearings breathe; they eventually become contaminated. Now, with Lubriflush, bearings are fully grease-sealed to eliminate contamination under normal operation. When severe conditions require re-lubrication for longest life, Lubriflush automatically purges and renews the lubricant, therefore prolonging bearing life.



Other U. S. Motors features

- **Asbestos-Protected Windings**
- **Normalized Castings**
- **Annealed Steel Laminations**
- **Streamlined, Shielded Housings**
- **Solid Centricast Rotors**
- **Dual Cyclone Ventilation**
- **Deep-Groove Ball Bearings**
- **Factory-Exchange Stators**



Lubriflush
AT NO EXTRA COST

Request Lubriflush Bulletin 1549 and Complete Line Bulletin 1543

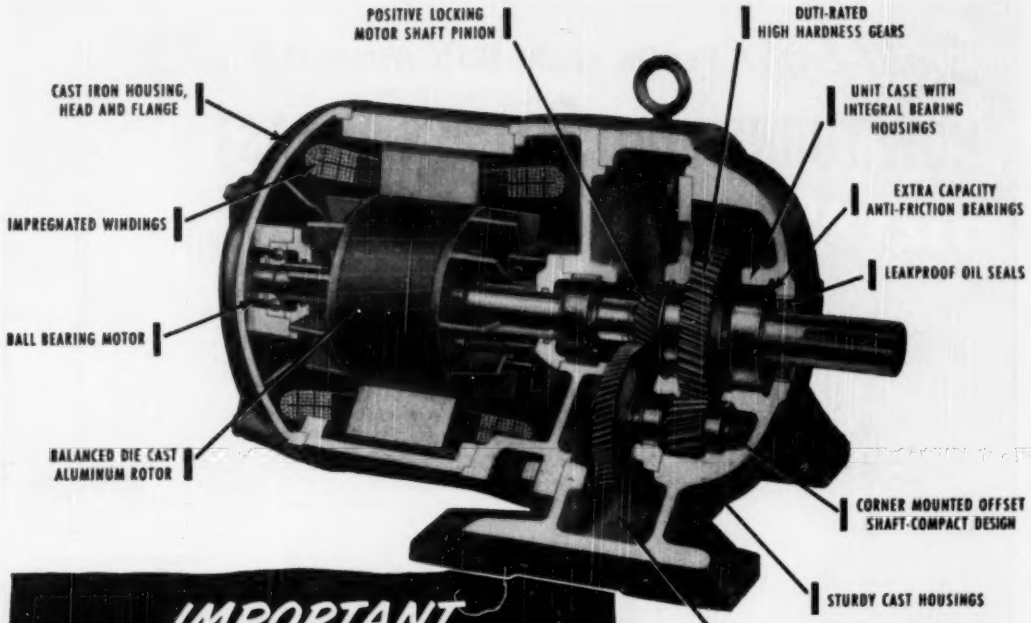
12 times more lubricant volume

Note in above drawing the increased lubricant capacity of U. S. Lubriflush bearings—actually 12 times the volume of grease used in a standard shielded bearing.

U.S. ELECTRICAL MOTORS Inc.

PACIFIC PLANT: Los Angeles 54, California ATLANTIC PLANT: Milford, Connecticut

Atlanta 3, Ga.; Bakersfield, Calif.; Boston 16, Mass.; Chicago 8, Ill.; Cincinnati 16, Ohio; Cleveland 14, Ohio; Dallas 9, Texas; Detroit 2, Mich.; Fresno 1, Calif.; Houston 4, Texas; Indianapolis 4, Ind.; Milwaukee 2, Wisc.; Minneapolis 2, Minn.; New York City 6, N. Y.; Philadelphia 2, Pa.; Pittsburgh 2, Pa.; San Francisco 7, Calif.; Seattle 4, Wash. *Distributors and Agents in all principal cities.*


POSITIVE LOCKING MOTOR SHAFT PINION
DUTI-RATED HIGH HARDNESS GEARS
CAST IRON HOUSING, HEAD AND FLANGE
UNIT CASE WITH INTEGRAL BEARING HOUSINGS
IMPREGNATED WINDINGS
EXTRA CAPACITY ANTI-FRICTION BEARINGS
LEAKPROOF OIL SEALS
BALL BEARING MOTOR
BALANCED DIE CAST ALUMINUM ROTOR
CORNER MOUNTED OFFSET SHAFT-COMPACT DESIGN
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LARGE OIL RESERVOIR— SPLASH LUBRICATION

IMPORTANT ADVANTAGES TO YOU IN

FOOTE BROS.-LOUIS ALLIS GEARMOTORS

Foote Bros.-Louis Allis Gearmotors offer you these advantages:

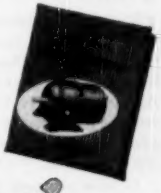
- high quality
- improved efficiency
- sturdy dependability
- greater compactness
- longer life

They are available in single, double and triple reductions in output speeds of 780 down to 7.5 r.p.m. Ratings range from 1 h.p. through 75 h.p. Open drip-proof, splash-proof, enclosed and explosion-proof motors are available.

These gearmotors have sturdy cast housings, streamlined inside and out. Precision helical gears have file-hard tooth surfaces and tough, resilient cores, giving long life and maximum load carrying capacity. Mail the coupon for bulletin GMA.

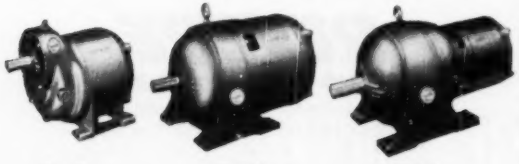
FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. Q., 4545 S. Western Ave. Chicago 9, Illinois

Bulletin GMA giving complete rating tables and sizes sent on request



FOOTE BROS.

Better Power Transmission Through Better Gears



Single Reduction *Double Reduction* *Triple Reduction*

Foote Bros. Gear and Machine Corporation
Dept. Q, 4545 S. Western Blvd., Chicago 9, Illinois

Gentlemen: Please send me a copy of Bulletin GMA with information on Foote Bros.-Louis Allis Gearmotors.

Name.....

Company.....

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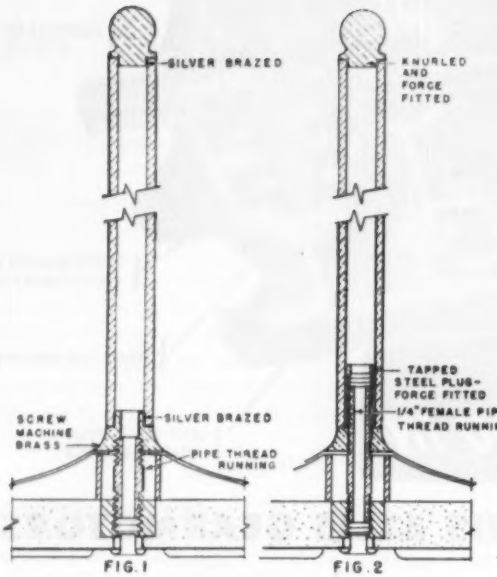
Sight-Light FLOOR LAMP *Sub-Assemblies*

NOW TURNED OUT 3 TIMES AS FAST



HERE'S HOW IT WAS DONE

Fig. 1 shows the two spots that formerly were silver brazed, and the screw machine brass piece that joined the stem with the base. Fig. 2 shows how top knob and machined brass section that joins the stem with the base are force fitted, eliminating 2 brazing and finishing operations, thus strengthening the lamp and making possible faster assembly and disassembly. Fig. 3 shows base construction simplified even further . . . single screw machine part in the base does the work of three separate parts.

Lamp stem is Revere ¾" O.D. x .680"—.6835" I.D. 70-30 brass tube hard drawn. Support bracket is ¼" x 1¼" Revere Brass Strip while the outside floor base spun shell is made from 12" wide x .0253 Revere Brass. Screw machine parts at top and base of lamp are Revere 240 type screw machine rod.

Joint efforts of Revere and Plainville Metal Works resulted in elimination of 2 silver brazing and finishing operations . . . faster assembly.

IN working with manufacturers on their various problems, Revere not only takes into consideration how its products can be used to help solve these problems, it also delves into the production methods employed. As a result there have been many cases where Revere and the manufacturer have collaborated to work out new production methods that have not only produced a better product but have also cut production costs.

Newest example of this is the manner in which Revere collaborated with the Plainville Metal Works, Plainville, Conn., in developing the Sight-Light patented reading lamp which they manufacture for the Sight-Light Corp., Deep River, Conn. Originally the knob at the top of the lamp stem was silver-brazed in. Revere suggested this could be a force fit.

Formerly, there had been a screw-machine brass trim section at the base of the lamp stem which had a shoulder on it that was also silver-brazed into the tube. A ¼" running pipe thread nipple with an unthreaded section anchored this screw machine part to the weighted base which was covered by a spun brass disc.

The engineers at the Plainville Metal Works tried various ideas to improve this construction. The final result was a machined section of solid brass that is joined to the lamp stem with a force fit, while the opposite end of this section is threaded for fastening to the base.

Results: 1. Elimination of two silver brazes. **2.** Elimination of two finishing operations, one of which was acid cleaning, and the other, the removal by hand of the discoloration caused by the acid cleaning. **3.** Subassemblies turned out 3 times as fast through a new, faster assembly method that permits finishing before assembly on a mass production basis instead of by hand. **4.** A substantially stronger lamp. **5.** A trim, one-piece screw-machine part at the base that is turned out faster and in a single machine set-up.

Perhaps Revere can be of help in developing or improving your product—cutting your production costs. Why not tell Revere *your* metal problems? Call the Revere Sales Office nearest you today.

REVERE

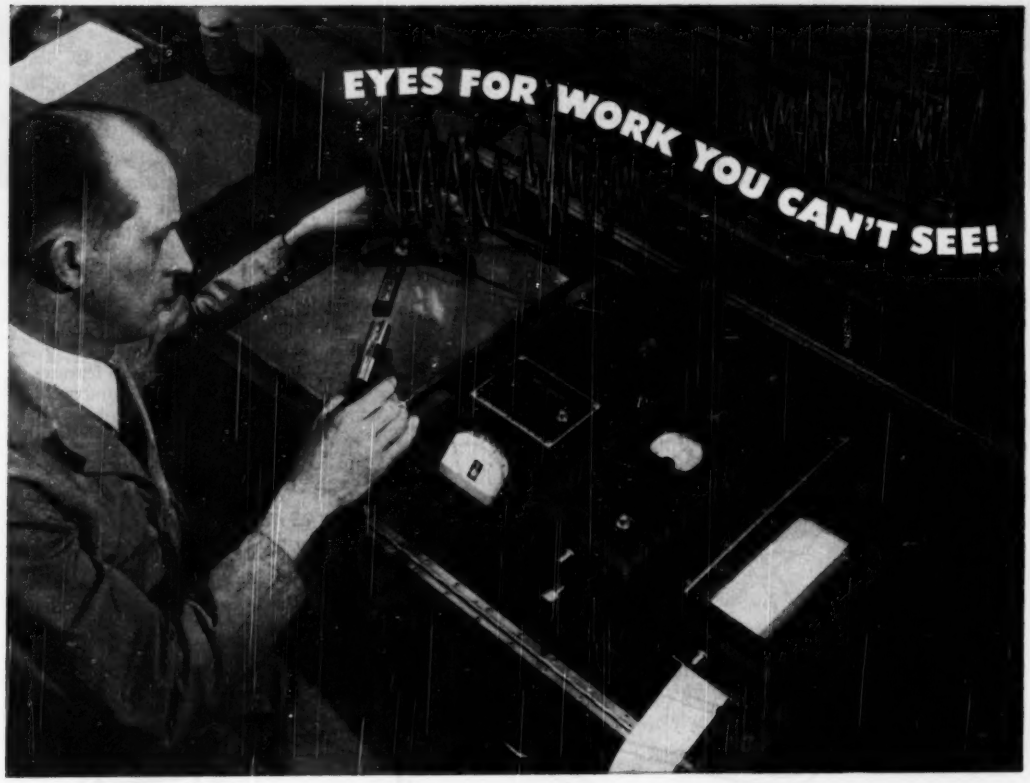
COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

• • •

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.



How to measure surface finish to less than 1/1,000,000 of an inch

● The Brush Surface Analyzer gives exact measurement of surface finishes to less than 1/1,000,000 of an inch—and provides a permanent record of each measurement as well as indicating the average finish in micro-inches. This super-sensitive measuring and recording device is rapidly becoming indispensable in more and more industrial plants where precision work is demanded.

One user, **Commercial Centerless Grinding Company**, of Cleveland, Ohio, employs the Brush Surface Analyzer to record the surface finish of instrument parts. They say, "Until just a few years ago, customers specified just 'smooth finish' when accurate finishing was wanted. Today, many of our work orders carry exact specifications, often requiring tolerances as low as one micro-inch.

"We use our Brush Surface Analyzer to make certain that all surface specifications are being met, and to furnish the customer with a permanent record of our inspection results."

Commercial Centerless has found that this builds customer confidence and product endorsement that brings increased business.

If you manufacture or use precision parts, find out how you can benefit from the accurate measurements and proven results made possible by Brush Recording Analyzers. Write today for more information.

THE *Brush* DEVELOPMENT COMPANY
3405 Perkins Avenue, Cleveland 14, Ohio, U. S. A.
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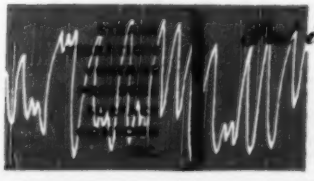


il in writing with a

BRUSH RECORDING ANALYZER

STRAIN ANALYZERS • SURFACE ANALYZERS • CONTOUR ANALYZERS • UNIVERSAL ANALYZERS • UNIFORMITY ANALYZERS

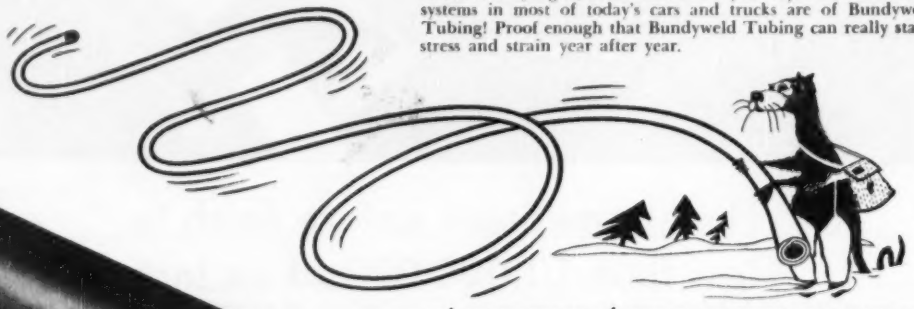
Why Bundyweld is

FISHING around for a tubing?
Whatever your product, whatever the tubing application you have in mind, trust Bundyweld to meet all your musts, and more.

No other tubing has all Bundyweld's features, for no other tubing is *made* like Bundyweld. It's double-walled from a single strip! Result: the amazing combination of Bundyweld advantages you'll find below.

BUNDYWELD BRAKE LINES ARE REALLY ASTOUNDING, THEY'LL LAST FOR YEARS THROUGH VIBRATION AND POUNDING.

If your top tubing requirements are *strength and high resistance to vibration fatigue*, here's the cue for you: Hydraulic brake line systems in most of today's cars and trucks are of Bundyweld Tubing! Proof enough that Bundyweld Tubing can really stand stress and strain year after year.



IT'S LIGHTWEIGHT, IT'S STURDY, IT FORMS LIKE A CHARM, YOU CAN HANDLE IT ROUGHLY..NO DAMAGE OR HARM.

With all its stamina, Bundyweld fabricates with unbelievable ease. It sails through practically any machining operation; bends more readily, takes more bending without collapsing or weakening structurally. Your production lines can turn out radiant heating grids, tubular frames, beer coils or other fabricated units without a hitch.

First, a single strip of basic metal, coated with a bonding metal, is . . .

rolled twice around into a tube of uniform thickness, then . . .

passed through a furnace. Bonding metal fuses with basic metal, presto—

Bundyweld . . . double-walled and brazed through 360° of wall contact.

the reliable tubing

WE LITERALLY..LATERALLY ROLL IT UP DOUBLE, GAIN GREAT EXTRA STRENGTH THAT FREES YOU FROM TROUBLE.

Bundyweld is double-walled from a single strip and brazed through 360° of wall contact. It's stronger walled, yet thinner walled; sturdier, more rugged, amazingly leakproof, yet light in weight as well. No wonder you're so apt to find Bundyweld *the* answer to a knotty tubing application where all other tubing has failed.

EVERY BIT OF YOUR ORDER GETS CHECKED WITHOUT FAIL, FOR LENGTH, AND STRENGTH, AND FREEDOM FROM SCALE.

Bundy shipments roll into your plant, checked by us as if they were jewels. Bundy crews watch length, strength, walls, I.D., O.D., bursting strength, freedom from scale . . . everything. *Your* crews can concentrate on production, instead of costly double-checking.

IF A TRICK TUBING BEND HAS YOU 'TWIXT AND BETWEEN, ODDS ARE WE KNOW HOW WITH A BENDING MACHINE.

Repeatedly, Bundy engineers have produced some of the most intricate bends *to order*. And when a bending fixture hasn't existed, Bundy has designed it. Bundy clients make substantial savings through this service alone (not to mention savings in production costs from the special qualities of Bundyweld Tubing itself). Bring that bending problem to Bundy!

IF *you* need a tubing, here's a tip that will pay:
Hook onto Bundyweld, right now—today.
We make it in nickel, in Monel and steel;
They all cut your costs and add product appeal.

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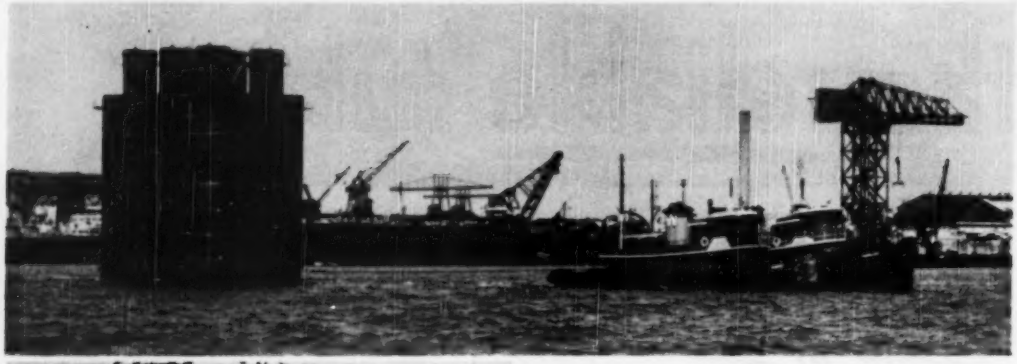

FLOATING A 2000 TON BRIDGE CAISSON

The caissons shown at the left are two of six being built at Newport News for the York River Bridge in Virginia. They are fifty-two feet by sixty-six feet in cross section and were built to a height of 110 feet. During construction sixteen feet of concrete was poured around the six dredging wells of the bottom sections of the caissons for stability in floating. They were floated from the dry dock in which they were constructed and towed to the site of the bridge fifty-seven miles away.

In addition to caissons many other types of heavy equipment have been built at Newport News in recent months. The plant extending over 240 acres, includes complete machining, casting, forging and other facilities which offer all of the advantages for the execution of the complete job. Your inquiries are invited.

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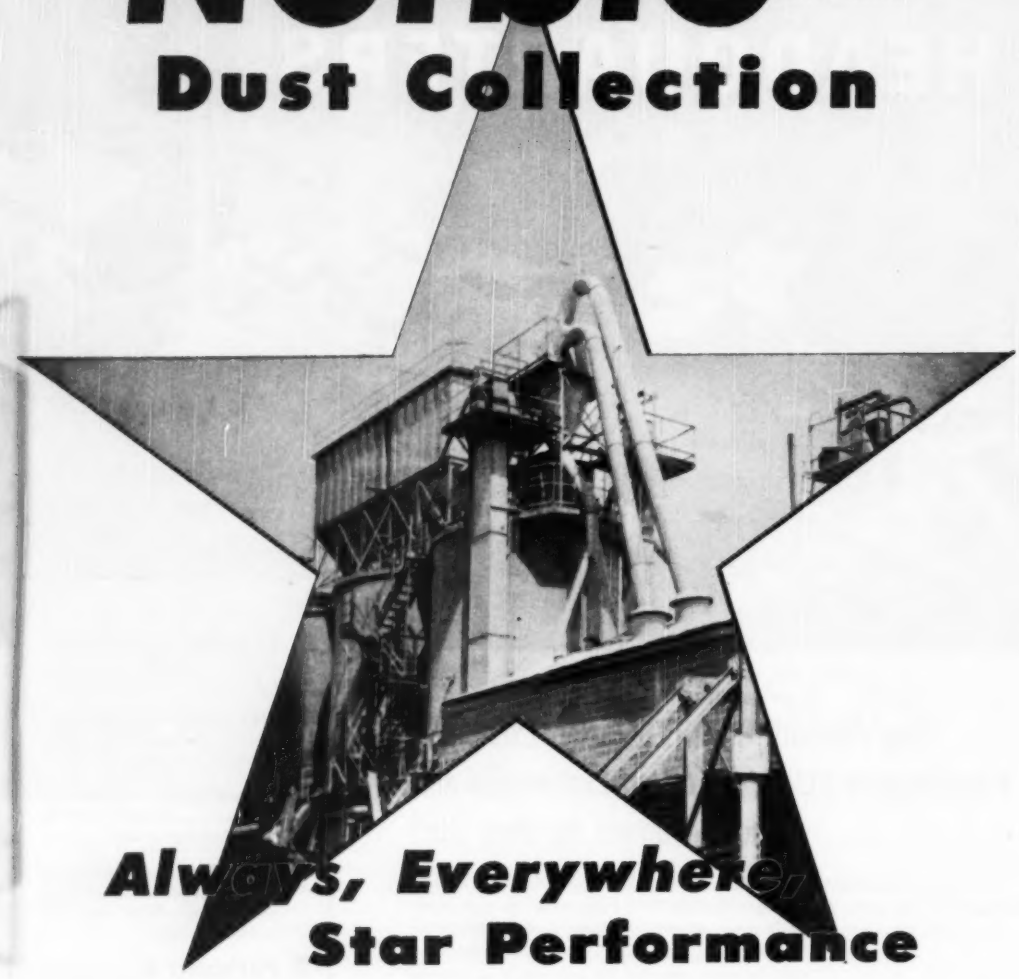

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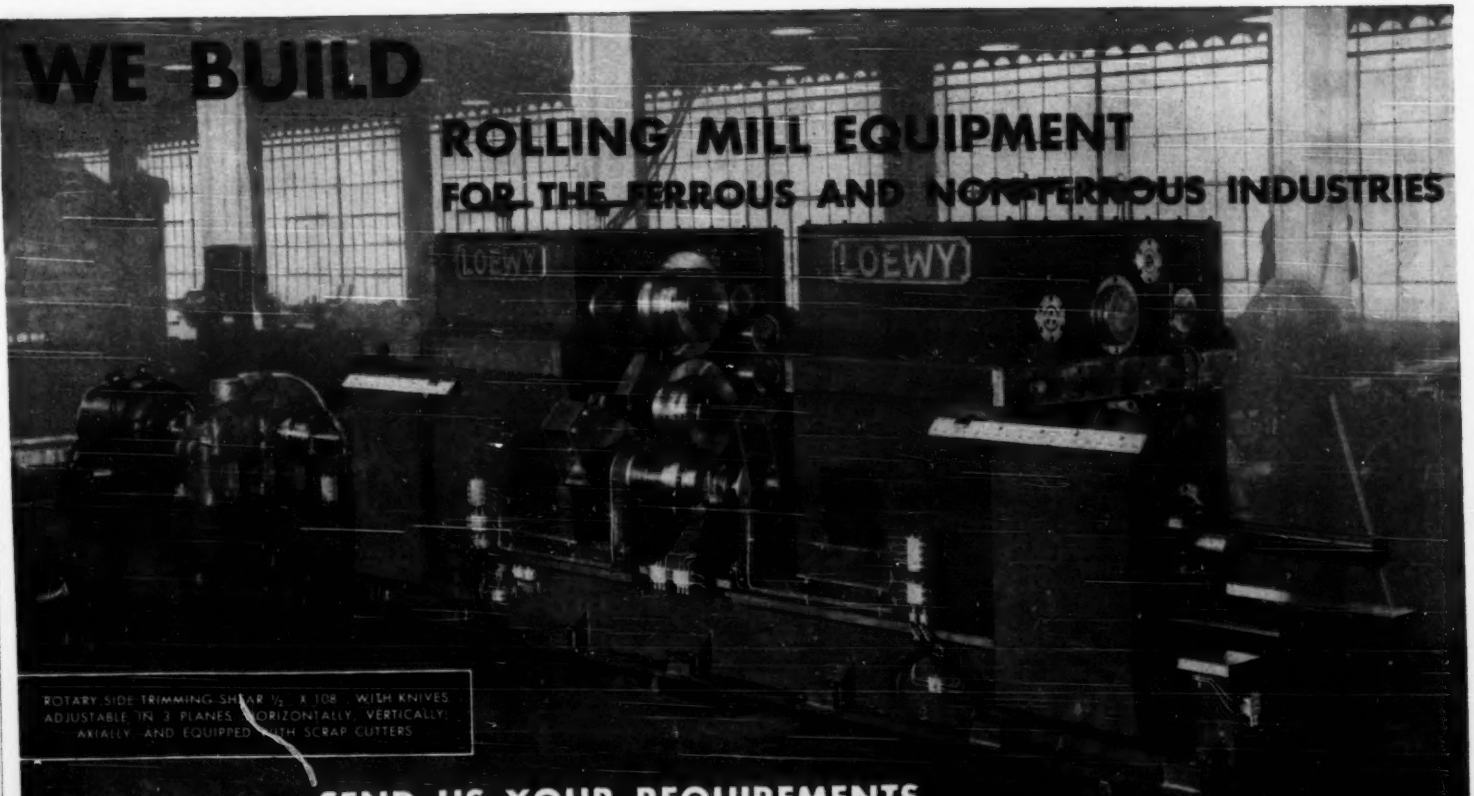

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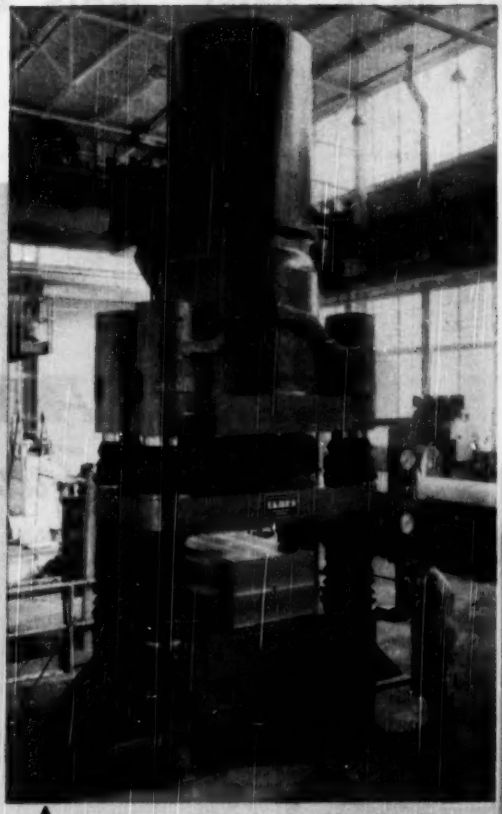
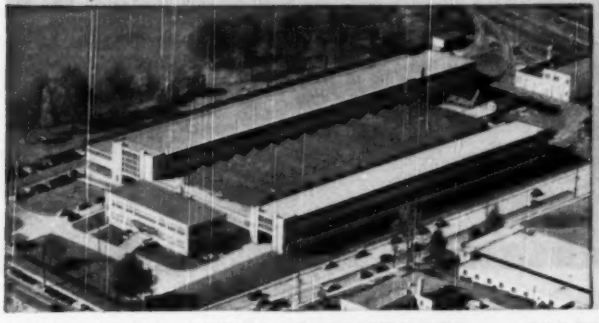
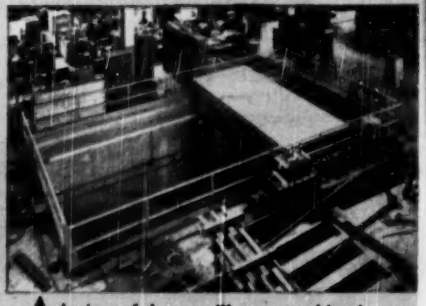


▲ This 2000-ton Elmes Abrasive Wheel Forming Press is one of the first large units produced in Elmes' new plant. The press is lever-controlled with two pressures available. Rugged construction assures minimum deflection.

▼ Aerial view of the new Elmes plant—one of the finest in the industry. The most modern precision production equipment and extensive working areas make possible the building of Elmes Hydraulic Presses in a greater variety of types and sizes, both standard and special designs.





▲ A view of the new Elmes assembly pit for erecting presses of unusual height. Sectional pit covers permit simultaneous erection of several normal-height presses having sub-floor assemblies.

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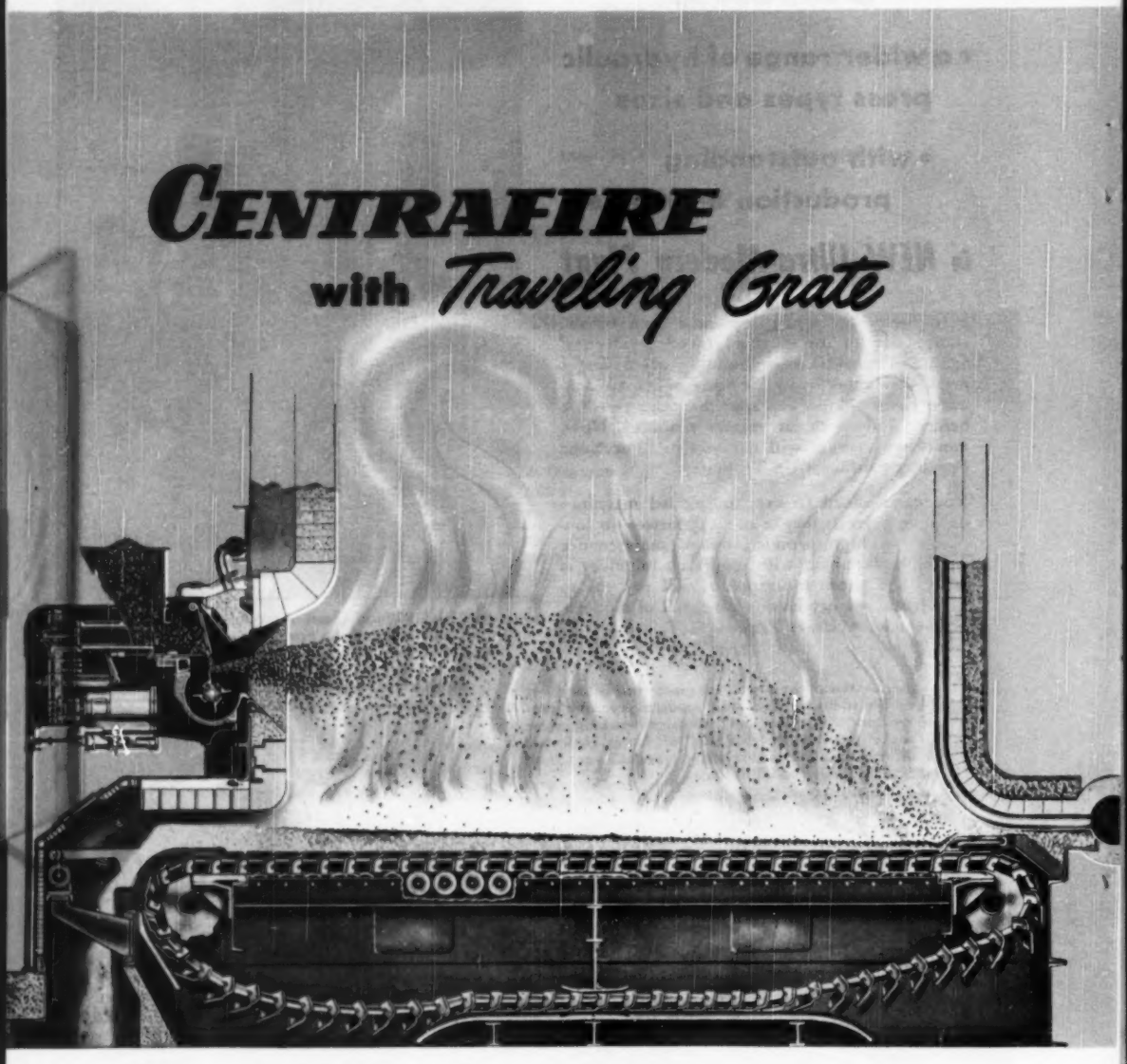

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The outstanding performance of the Centrafire with Traveling Grate stems from features that are built in—not added as accessories.

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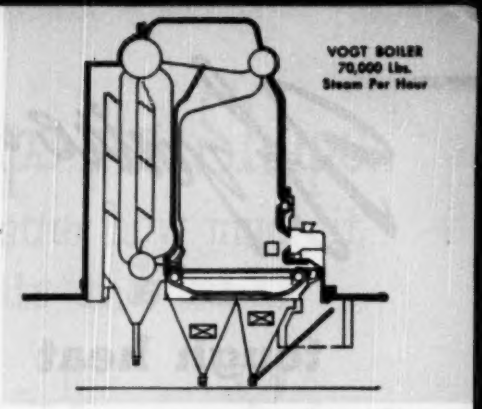
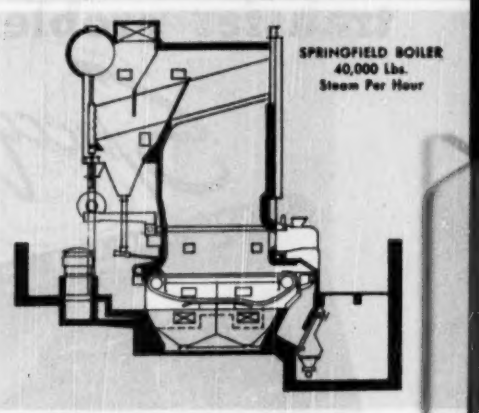
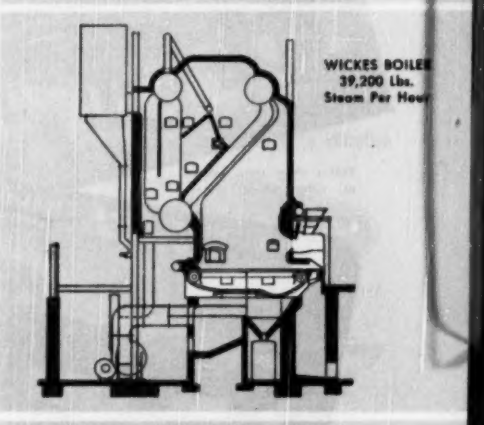
Fuel distribution adjusted automatically to air flow through front and rear grate sections results in intimate mixing of fuel and air for thorough combustion.

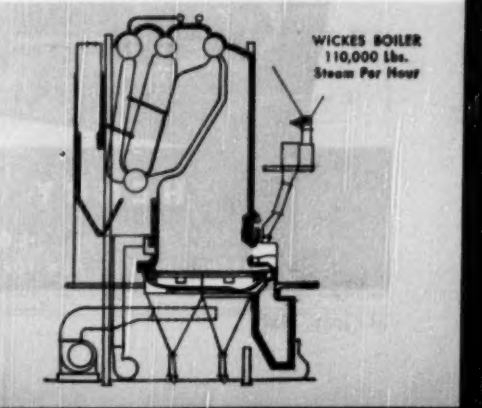
The Centrafire's range extends upward of 300,000 lbs. of steam per hour. Its adaptability to deep, narrow furnaces permits use of the most economical boilers.

It will pay you to get the full Centrafire story. Ask your Westinghouse representative for complete data, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-30304









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Fouling of the inner pipe surfaces of Vogt Chillers is eliminated, because they are swept clean continuously during operation by patented spiral, spring type scrapers. And these clean surfaces achieve the highest possible rate of heat transfer between the solution and the refrigerant.

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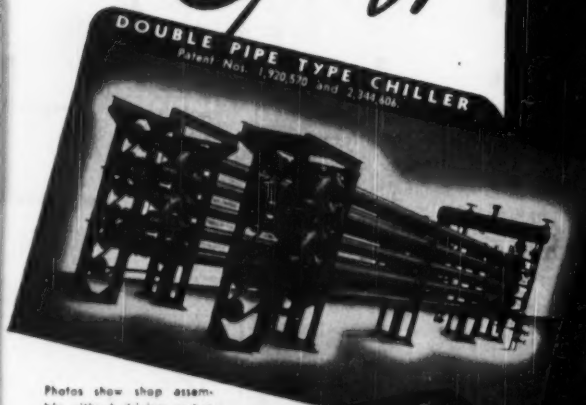
MULTI-PIPE TYPE CHILLERS, for direct expansion, have large jacket shells each containing seven inner pipe sections and employ volatile refrigerants such as ammonia, freon, propane, etc.



Photos show shop assembly without driving motor.

Our engineering staff is qualified by training and experience to help you find the right answers to your heat transfer problems. Their recommendations are available without obligation.

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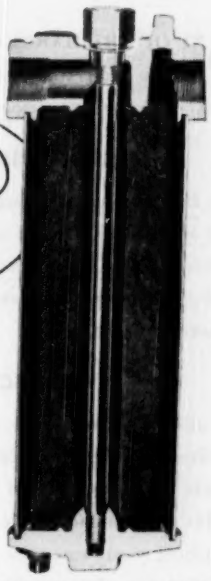
Put the Cuno MICRO-KLEAN filter on almost any kind of a diet . . . and it will stay healthy longer than any micronic filter you know of.

Handling a wide range of fluids at a wide range of flow rates . . . the MICRO-KLEAN won't *shrink* or *swell* or *channel*. So there's no place for the fluid to go except where it's supposed to . . . through the cartridge.

Its dirt capacity is *double* that of any comparable filter—so its life is that much *longer*.

Finally, you can install it—inside or outside your equipment—with no trouble at all, because it takes up less space.

Check the box nearby for an explanation of MICRO-KLEAN's exclusive performance.



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Why won't MICRO-KLEAN *shrink or swell or channel?*
Because the fiber structure is resinous-impregnated and polymerized, and resists any deteriorating effects of most fluids and contaminants.

Why does MICRO-KLEAN *have double dirt capacity?*
Because exclusive "graded density in depth" permits smaller particles to penetrate to varying depths—no surface-loading.

Why does MICRO-KLEAN *take up less space?*
Because the cartridge is *all filter*—no structural elements, no cans, bags, springs, inserts. Full-flow filtration needs much less room.

Also important: pressure drop is low . . . cartridge changing is easy . . . and CUNO MICRO-KLEAN IS GUARANTEED TO REMOVE ALL SOLIDS LARGER THAN SPECIFIED . . . PLUS A LARGE PROPORTION DOWN TO 1 MICRON!

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Cuno MICRO-KLEAN filters come in varying densities (10, 25, 50 microns) . . . capacities from a few to more than 800 gpm . . . connections from ⅜ in. IPS to 6 in. flanged . . . single or multiple cartridge units.

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Fluid Conditioning

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Its Brinell hardness ranges from 550 to 650 when sand cast, and 600 to 725 when chill cast.

This extreme hardness . . . at the moderate price of NI-HARD . . . provides abrasion resistance at lowest ultimate cost.

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The strength and toughness of NI-HARD castings are increased fifty to eighty per cent, without loss in hardness or abrasion resistance, by a stress relieving treatment at 400-450°F. User experience has demonstrated the merit of specifying this treatment.

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Applications include: grinding balls, ball and rod mill liners, slurry pump parts, flotation impellers, piping, scoop lips, classifier shoes, roll heads, pulverizer rings, chutes and hopper liners, muller tires, plows, pug mill knives, clay augers. Also coke grizzly discs, crusher rolls, coal mine pumps, dredge pump impellers, liners, rings and sleeves. Also industrial food grinding burrs and attrition mill plates.

AVAILABILITY

Try NI-HARD wherever you encounter severe abrasion. See for yourself how its remarkable properties minimize replacements and repairs.

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Full information is yours for the asking. Write for the booklets, "Engineering Properties and Applications of NI-HARD", and, "Buyers Guide for NI-HARD Castings."

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 72 NUMBER 7

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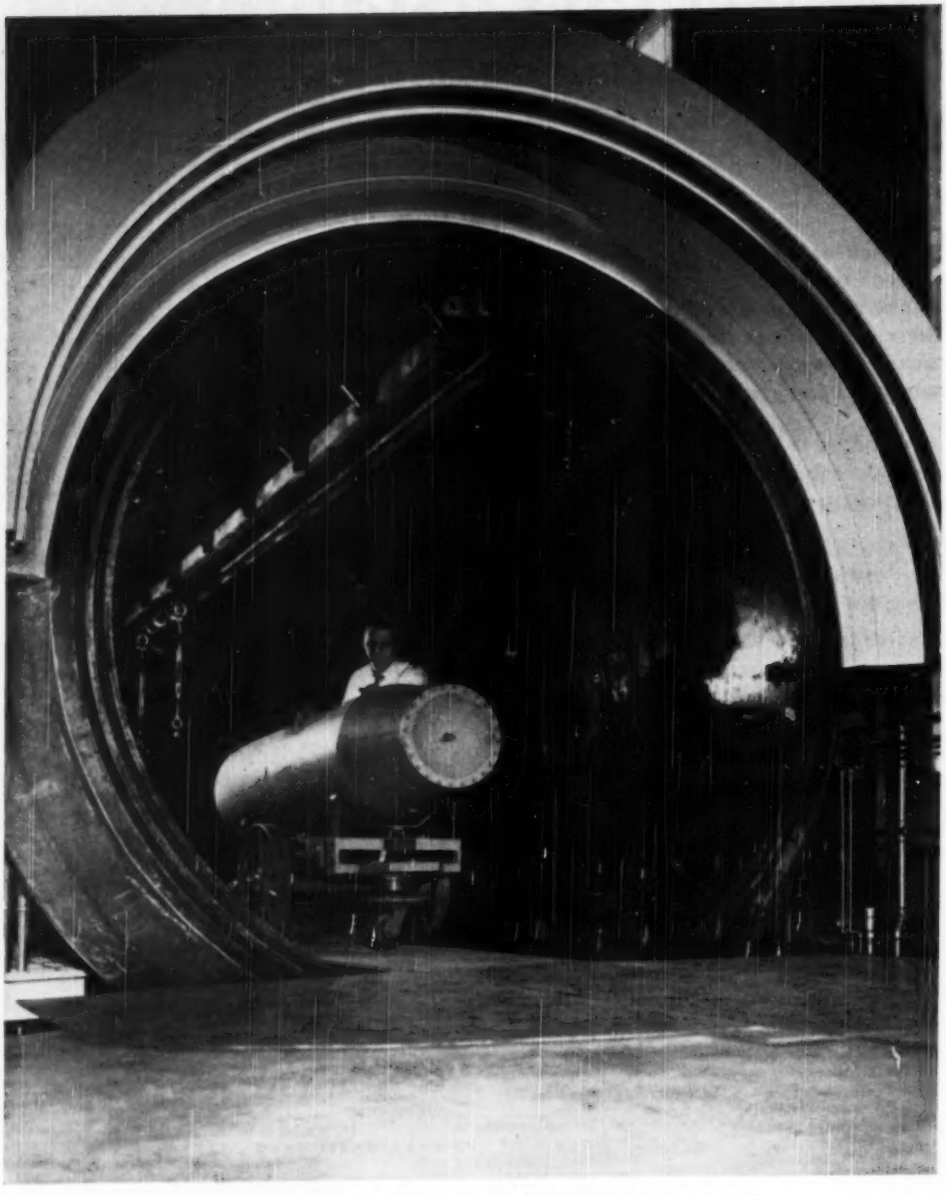

The Deep-Sea Pressure Tank in the NOL Environmental Laboratory

(It is used to simulate water pressures equal to those encountered down to one-half mile beneath the surface of the ocean, a maximum of 1000 lb per sq in. Ordnance items as large as a midget submarine can be tested in this tank, which holds 15,000 gallons of water and weighs approximately 210 tons when filled. See pages 539-542 of this issue.)

VOLUME 72
NO. 7

MECHANICAL ENGINEERING

JULY
1950

GEORGE A. STETSON, *Editor*

Too Many or Too Few?

ARE there too many engineers or too few? Will the graduates of engineering colleges in the next few years have difficulty finding employment? Should young men about to enter college study for the engineering or some other profession?

These and related questions are being asked by parents of high-school boys, by students in the engineering colleges, by recent graduates, by engineering educators, by engineering societies, and by employers.

A brief survey of the situation as it existed in the spring of 1950 was presented by Henry H. Armsby, associate chief for engineering education of the Office of Education, Federal Security Agency, in an article "Engineers—Too Many or Too Few," to be found in *Higher Education* for April 1, 1950, published by that agency.

According to Mr. Armsby, serious shortage of engineers resulting from war conditions was a strong factor in causing an unprecedented number of students to enter engineering colleges in 1946. The 93,000 freshmen of that fall constituted 8.6 per cent of high-school graduates as compared with a prewar normal of 3.2 per cent. Since 1946 freshman engineering enrollments declined to 64,000 in 1947, 48,000 in 1948, and 42,000 in 1949, so that the present engineering freshman class is once more about 3 per cent of the total high-school graduates.

Of the 93,000 freshmen of 1946, about 51,000 were seniors in 1950 with an expected number of 47,000 graduates. Based on prewar "survival ratios," engineering degrees conferred in 1951 will be about 35,000, in 1952 about 25,000, and about 19,000 in 1953. "Prewar ratios applied to Office of Education estimates of future high-school seniors," Mr. Armsby states, "indicate a steady decline in total annual engineering graduates beyond 1953 to a low point of about 15,000 in 1957, followed by a slow rise to about 21,000 in 1965."

What is the current demand for engineering graduates? Mr. Armsby quotes the Bureau of Labor Statistics estimates of "an annual need for engineering graduates of between 17,000 and 18,000 per year during the early part of the 1950–1960 decade, rising to an average annual demand of about 22,000 per year by 1960," based on "actual engineering jobs." He also quotes from a recent survey of Engineers Joint Council the actual placement results which indicate that "about 35,000 graduates of last year's class have actually been placed in jobs which utilize their engineering training, a figure almost twice as large as the estimate of the Bureau of Labor Statistics. About 3000 entered graduate schools, and the employment status of about 7000 is unknown."

In an address at the University of Denver on Engineers' Day, April 27, 1950, E. G. Bailey, past-president ASME, said: "The General Survey Committee of the Engineers Joint Council reported in the 1949 survey an indicated total demand for about 25,000 new engineering graduates. Its later survey, extending up to last November, covering engineering schools with three fourths of the year's total graduates, showed that actual placements were about 50 per cent higher than the previous estimates. Total placements for the year presumably were still greater. The major part of the unpredicted employment was undoubtedly with a large number of smaller companies, not included in the survey of the industry. Many small companies are now employing engineering graduates which deferred employing them due to the shortage of supply during and shortly after the war." In the same address Mr. Bailey said: "May we learn to use statistics wisely for what they are worth, but we should not let statistics and diverse opinions confuse industry, educators, or embryo engineers. Football games are not won by statistics; they are won through incentive, skill, and team work. In my opinion we need engineering more than at any time in our history."

Getting a Job

MR. BAILEY's optimistic opinion, "we need engineering more than at any time in our history," will be echoed by a majority of engineers. It should give encouragement to young men in high schools, their counsellors and parents, and to engineering graduates. The future is bright. And even if it may turn out that the graduates of 1950 will not be absorbed immediately upon graduation in engineering positions of their first choice, a competent and ambitious young man will have principally himself to blame if he is left to wither on the vine.

With production of engineering graduates at a high level, competition for jobs will be keen. Competition is always tough on the person who has to meet it, but it makes us resourceful. Probably the young men of 1950 wish they were graduating under conditions that prevailed several years ago when it was a case of accepting the most attractive of several offers made by company representatives on their recruiting missions. If there are not enough of those jobs to go around, then the young men will have to find their own jobs. This, they will be told, is not as much of a handicap as it may appear to be. Certainly in the past young engineers have left college at times when jobs were hard to come

by. In a sense such men have been fortunate. Many of them have done better than the average graduate who has not felt the stimulus of keen competition. But such generalities are likely to be cold comfort to the lad who must find a job or make one for himself. Even though the world may be his oyster, a few ideas on the opening of oysters may not be amiss.

In this connection, Allen P. Richmond, Jr., personnel officer of the American Society of Civil Engineers, has prepared a memorandum, "How to approach the business of getting a job." Mr. Richmond suggests that engineering students "organize and carry out their job-seeking projects as systematically as they would plan the design or construction of a building or a bridge." Toward this end, he states, "the most important decision is the field of work desired, and, if a choice can be made, the function or kind of work to be performed in it." He suggests aptitude tests "as a guide in selecting the kind of work in which he may expect the best chance of success." Having analyzed "interests and abilities . . . . it will be advisable to look beyond possible entrance jobs towards 'what I want to become.'" If he cannot obtain at once the kind of work desired, "the young engineer can always keep headed toward the desired goal even if he feels that he must work temporarily at something different."

This is a good start, but there are other factors to consider, which Mr. Richmond discusses, e.g.: Shall it be in a small or a large firm? Shall it be in private enterprise or in some public agency? In assessing personal abilities and possibilities of employment, the young man is urged to make use of a Self-Appraisal Form published by Engineers' Council for Professional Development.

Hints on how to proceed after decisions are taken are given by Mr. Richmond as follows: "Various mediums are available for getting in touch with prospective employers, including contact with the placement officer of the college, inquiries among employers or their employees personally known to the student (especially alumni of the college), registration with the Engineering Societies Personnel Service, registration with other employment agencies, correspondence with prospective employers not personally known to the student, and personal calls upon likely firms. The applicant should also read the job advertisements in engineering periodicals and newspapers."

How to find names and addresses of possible employers, how to draft a letter, what to do about interviews, and caution in selecting an employer are also discussed briefly by Mr. Richmond. Appended to the memorandum is a bibliography of helpful reading.

It would be natural that engineering students, faced with the possibility of finding a relatively unfavorable market for their services in 1950, and noting the salaries they might expect to receive provided they had masters or doctors degrees, should consider entering graduate schools instead of seeking immediate employment. With median starting salary rates of $255 for men with bachelors degrees, $320 for men with masters degrees, and $445 for men with doctors degrees, the temptation to undertake graduate study might prove to be strongly appealing. It should be remembered that not every engineering student has the ability or temperament to carry on his schooling beyond the undergraduate level or to undertake in later life the kind of work for which advanced studies would fit him. Decision to postpone entry into actual engineering practice should be taken only after very careful study of the factors involved and probably on the advice of men in the colleges and industry who have mature judgment in such matters. And it must not be forgotten that opportunities for continuing graduate study after one is employed in industry are becoming more abundant every day.

Engineering Frontiers

IN a static or slowly changing economy, employment opportunities become traditional. The work of the mason, the cooper, the cordwainer, the vintner suffered little or no change for generations. As boys reached the working age, opportunities for employment were offered in these and other trades. Everyone knew what was involved—what the workman did.

Today, with rapid social and economic change, many of these trades have disappeared, and even those which have persisted have changed greatly. New skills are needed; old ones have become obsolete. And with the change, new job opportunities also have developed. The traditional patterns are changing rapidly as new ones appear on the scene.

What is true of the trades is even more true of opportunities for engineering employment. A few persist, but with advances in technology and science and with the ever-increasing acceptance of the engineer as a man able to turn his skill to almost every aspect of industry and business, opportunities for engineers multiply.

This is indeed a fortunate circumstance, particularly in times when, like the present, the new crop of engineering graduates may be too large to be absorbed in the traditional patterns of engineering practice. For the need presses us to expand the frontiers of engineering, to invade nontraditional fields, and to seek opportunities in the new ones which scientific progress will bring forth.

Along such lines of thought the American Society for Engineering Education, through its Division of Relations With Industry, has prepared for and is distributing to industry a pamphlet "Engineers Offer New Frontiers." It recites case histories of the success of engineering graduates in solving problems in areas of business and industry where usually little attention is given to the possibility that engineers may be the ones who can provide the solutions. And it ends with the statement: "A young but well-selected engineering graduate is ready to demonstrate that his services can help your company to maintain its position on the frontiers of industry. Would you like to give him the opportunity?"

The pamphlet was designed to appeal to employers. But it carries a message to young engineering graduates as well. It will help him to get his mind out of the rut of thinking that only traditional forms of engineering employment are possible for him. His reaction on reading the pamphlet should be: I am that young man.

RESEARCH MANAGEMENT

By RALPH D. BENNETT

TECHNICAL DIRECTOR, NAVAL ORDNANCE LABORATORY, SILVER SPRING, MD.

TIME was when research was carried on, often in odd corners of university laboratories, by individuals who by happy coincidence had the driving curiosity to explore Nature and the intellect to formulate her laws, and at the same time by luck or good management were able to subsist on accumulations of wealth gathered by provident patrons, and dedicated to this worthy purpose. Nowadays, research is as often carried out by teams as by individuals and employs equipment that is massive and impressive if not downright horrendous. Research is housed in multimillion-dollar laboratories and is prosecuted either as a business itself, or as an essential adjunct to continued solvency of great business enterprises.

NAVAL ORDNANCE LABORATORY

The venture on which much of the author's experience has been based is the Naval Ordnance Laboratory. This laboratory inherits more than a hundred years of experimental experience of the United States Navy in the application of science to ordnance. It enjoys and profits from the munificence of the American people in its fine new plant at White Oak. It utilizes the services of more than two thousand of our citizens, who embody a very great variety of skills and who represent a great investment in education and experience. Finally, our laboratory is dedicated to the proposition that, under the Navy and in the Federal Government there can and will exist a fully effective productive research and development center, rendering an important service which it alone can supply, and which will constitute a profitable investment in national security for the Republic.

For research done by individuals or even small groups supported by endowment, little management is required. When it is carried out by teams, or large groups of teams using large and expensive equipment, the complexities of operation multiply. Management effort becomes necessary to maintain a sufficiently orderly atmosphere to permit the technical workers to carry out their tasks, and to supply the multitude of services and material things which they require. Further, the work of these great laboratories is a part of and geared to a much larger program.

In our laboratory our work program must tie in to the overall program of the Bureau of Ordnance. This in turn is geared to the program of the Navy, and to the program of the Department of Defense, the State Department, and the whole Federal Government. Our ability to supply management talent, which will on the one hand foster effectiveness in government research and development organizations, and on the other tie the efforts of these organizations together into a balanced coherent program upon which the technology of our defense can be based, may well be critical to our survival.

MANAGEMENT OF A RESEARCH ORGANIZATION

The management of a research and development organization must provide many things. Among the most important of these are the following:

(*a*) A program which ties into the sponsor's business well enough to get long-term support.

(*b*) A technical staff of competence adequate to carry out the program effectively.

(*c*) Physical plant, equipment, and supplies sufficient to enable the technical workers to carry out their work without undue delays.

(*d*) The technical and nontechnical staff necessary to provide support for the technical workers.

(*e*) Understanding adequate to provide a balance among the essential factors and to evaluate performance with sufficient perspective.

The definition of the program for a research and development organization is a responsibility of research management, guided by the requirements of a parent organization, and aided by the research workers themselves. The program must embody enough flexibility to permit adjustment to the effects of new discoveries, both within and without the organization; to allow stoppage of work in directions which prove unprofitable; to permit prompt initiation of work in areas which show promise; and to undergo easy adjustment to the requirements of changing times and conditions. Yet, at the same time, the program must show a high degree of over-all stability, for while an effective organization can be destroyed overnight, it can only be built over a period of years.

In our own program we have undergone many changes since the end of the war. We have inherited many half-completed programs which had been begun by OSRD and whose continuation was important to the Navy. We have exploited and advanced some of the areas where our late enemies were preeminent, basing our progress on the work which the ending of the war revealed. We have adjusted our activities to the redistribution of responsibilities concomitant with the unification of the armed services into the Department of Defense. Throughout all these changes we have maintained an effort whose total has fluctuated less widely than that of many industrial laboratories, and has proved more stable even than the programs of some of our universities.

A COMPETENT STAFF IS ESSENTIAL

An important feature in any program such as ours is that it contain a reasonable share of work in the more basic areas. The sponsor is always under pressure to get immediate results. If this pressure is allowed by research management to squeeze out all of the long-range work, and with it the thinkers who are most likely to perceive far-reaching advances, the organization eventually will go sterile, and the whole enterprise may never net the high yield of true research achievement.

The most important asset of any research or research and development organization is its technical staff. It is so important that, without reasonable competence in its staff, the investment in the organization may well be a waste of money. Furthermore, unless the staff has a sprinkling of genius which is willing to devote its efforts to the objective of the enterprise, great gains cannot be expected. Since the war the competition for talent in this field has been fierce, partly because of the continued high level of support to research institutions of all kinds by the Department of Defense, and partly because of the

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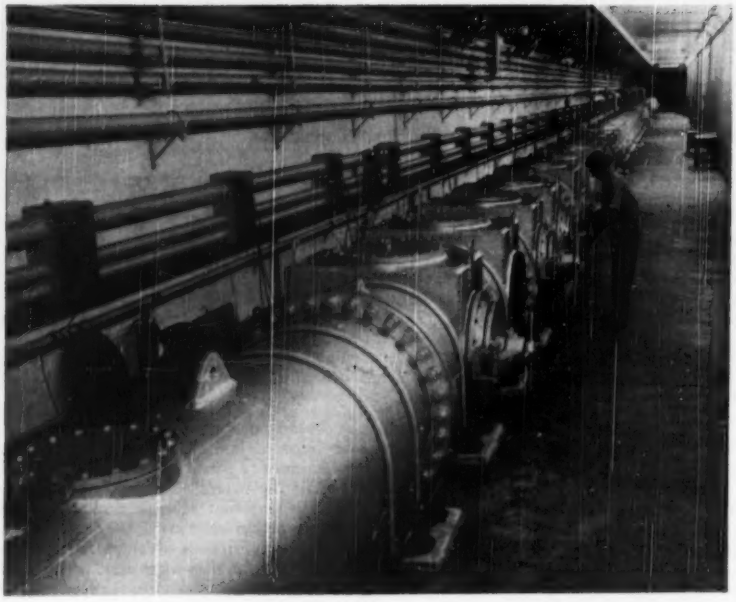
The opinions expressed here are the personal ones of the author and not necessarily those of the Navy Department.



THE NOL PRESSURIZED BALLISTICS RANGE IS A UNIQUE FACILITY

(It permits the firing of missile models under pressures ranging from vacuum to six atmospheres, yielding information at Reynolds numbers covering the whole span from supersonic-wind-tunnel conditions to full-scale flight.)

Naval Ordnance Laboratory Photo

need for many industries to catch up on their research and development by intensified programs. The shortage has been aggravated by our shortsighted policy during the war in suspending the training of persons who could contribute substantially in this field.

A general but vital requirement for the acquisition and retention of a competent staff is that it be offered an opportunity to do effective work under professional supervision, and be reasonably free of the restrictions and frustrations which can so easily intrude unless they are carefully watched by management. Another general but important requirement is that the problems which the organization is given to solve be of such a nature as to require a high order of talent and ingenuity, and that their importance to the general program, which in our case is the defense of the Nation, be obvious and assured. In this respect we are particularly favored. It is not clear that in the present state of development of our technology we can maintain our commitments abroad without surface traffic on the sea. The defense of surface traffic on the sea against aircraft and submarine attack offers a wide variety of technical problems whose difficulty and complexity are unequaled anywhere, and for whose solution the finest efforts of our best talent will be required.

OPPORTUNITY FOR ADVANCEMENT

Given sufficiently challenging problems, and an atmosphere in which work toward their solution can be carried on without undue frustration, the next requirement likely to interest an able young man is his opportunity for advancement. In this we are again favorably situated because of the youth of our organization as a group of large size. This has meant that our young men can go forward to positions of high responsibility at an unusually high rate of progress. Furthermore, it is the policy of the laboratory to aid in every way possible the development of our young men, so that they may be qualified at the earliest possible moment to hold positions of greater responsibility either in our own establishment or elsewhere. The steps we have taken in this direction include a very extensive training program in advanced scientific study. More than a quarter of our professional staff is engaged in organized and oriented scientific and technical study, or in the teaching of the classes which make it possible. Most of this work is carried on under the sponsorship of the University of Maryland, and its president and staff have considered it an important public responsibility to make the University's talents and facilities available for this instruction. It has been particularly important in the postwar years because so many of our people had their formal training curtailed by the demands of the war.

We find that training in purely technical areas is not sufficient for rapid advancement in an organization such as ours. The interrelation of our activities, and the proper distribution and correlation of effort for rapid progress become so important in an organization of our size that the ability to present ideas clearly and to deal successfully with individuals and groups of men becomes of vital importance early in the careers of many of our people. To enhance the capabilities of our people in this direction, we have over a period of years offered them the opportunity to improve their presentation of ideas vocally by formal training in public speaking. We have given them aid in the improvement of their skill at written presentation. We have also employed men who are recognized experts in the use of executive techniques to instruct our people by consultation and example in the conduct of meetings and conferences, in the adjustment of organizational groups for effective work, and in the development of coherent teamwork. Our efforts in this direction have paid handsome dividends by improved performance in the laboratory, and the results have accrued to many other establishments and agencies in the large number of NOL men who have gone out to positions of responsibility greater than we could currently offer. While such departures cause

A MODEL IS MOUNTED IN THE WORKING SECTION OF THE NOL SUPERSONIC WIND TUNNEL

(After the model is in place, winds blowing at speeds faster than sound will rush past the model. This particular nozzle produces flow at Mach number 6.5, i.e., 6.5 times the speed of sound.)

Naval Ordnance Laboratory Photo

temporary inconvenience to the laboratory, the result of our effort in development of men is by no means lost to the American people who support it. Such losses will not be fatal to the laboratory as long as we can keep a sufficient flow of able young men into the lower levels of our organization.

BENEFITS OF GOVERNMENT EMPLOYMENT

Employment in our laboratory and in the Federal Government offers a number of benefits which are perhaps worth passing mention. Our pay scale is well above that offered in most universities for similar work, though our standard of performance is in some ways more exacting. The Federal leave policy gives almost if not quite as much leisure for study and recreation as the teaching profession makes available under current conditions, and an accumulation of annual and sick leave up to the limit provides assurance of considerably more than half a year at full pay against accident or serious illness. The Federal contributory retirement system offers a better than average bulwark against the infirmities of old age, and the ability to transfer anywhere within the Federal system, retaining all rights and benefits, permits a wide choice as to geographical location, type of organization, and variety of work for which a scientist or research engineer is eligible.

The selection of new employees is on an immeasurably better basis than it was before the recent war because we now have local Boards of Expert Examiners, composed of operating scientists who set the examinations for, and evaluate the performance and experience of applicants. This makes it possible to recruit directly and intelligently for positions which may be open, and assures that the qualifications of applicants can, within the limitations embodied by law, be evaluated in the light of probable performance, estimated by persons skilled in the field in question.

In the last three years we have taken important steps in the assurance of a steady flow of able young people into our organization. We have employed college men for the summer between their junior and senior years on a trial basis, giving us and them an opportunity to investigate each other. By such a trial we greatly enhance the probability of a good fit on the part of young people who are invited to join our staff. We also have been able to establish arrangements with some of the well-known universities whereby the laboratory takes co-operative students for employment and training during alternate terms of their formal education. We look upon this as a prime source of competent talent.

We would like to employ a larger fraction of our staff at the fully trained level—those with the doctorate degree. This has not been possible on as large a scale as we desire because of the shortage of graduates in this category, which is only now beginning to be less critical, and our inability to compete salary-wise with the temporarily fantastic pay scales.

ADEQUATE PLANT NECESSARY

While much good work can be done in indifferent or substandard buildings, the availability of an adequate plant is a substantial asset in the effective conduct of research and development. In this the Naval Ordnance Laboratory is unusually fortunate at the present time, for it has just moved into a fine new plant, embodying all the modern advantages in the way of flexibility for use in research and development, and in the quality of the facilities and equipment which it houses. The location of the research plant is important, and we learned, as have many industries, that it is best separated from production activities.

The primary consideration in the location of our plant at White Oak was that it be in an area that was not so densely populated as to preclude the possibility of our people building adequate homes, and yet that it be not so remote from the advantages of a large population center as to be unable to supply reasonably good schools; to provide contact with other groups

of persons interested in similar work; to give access to universities competent to supply talent and training; within easy access to transportation to all parts of the country, and to adequate sources of supply. Our location on the fringe of Washington supplies all these requirements in an almost ideal way, and the management of the laboratory was exceedingly fortunate in being able to arrange such a location for the plant.

Our new and convenient structures, designed specifically for the purpose to which they are devoted, contain for the most part excellent technical equipment. All of it is good, some of it is superb, and some of our facilities, such as the supersonic wind tunnels, the pressurized range, our magnetic-materials laboratory, our explosives equipment, our anechoic room, and our environmental laboratory, are unique.

SOURCES OF SUPPLY

Another important need which management must meet is the quick and easy supply of materials and small pieces of equipment for the use of the technical staff. Without such supply, the scientific worker is in a continual state of frustration. He cannot do his job well, and if he has ability he is likely to seek other fields of employment. It is a tribute to the Navy supply system that under the alert young officers which we have had at White Oak, this system has been molded to the point where it meets these needs in a reasonably satisfactory manner. The system is still adjusting its procedures to better satisfy the special needs of research and development institutions.

EXPERIMENTAL SHOP FACILITIES

An organization which is engaged in fields of physical research must have available to it the means for creating, out of raw materials, experimental equipment and trial devices of many kinds. This need can best be met by an experimental shop which embodies a sufficient variety of machinery and skill to meet the normal needs of the establishment, and it must have access, by contract or otherwise, to additional establishments which can handle unusually large or rare varieties of equipment construction. The management at White Oak has solved this problem by the establishment of two types of model shops. We have a large central shop which handles the bulk of our work. We also have about a dozen small experimental shops scattered throughout the plant in which the engineer or his assistant can do small mechanical jobs. These branch shops employ two or three artisans who care for and supervise the use of the equipment and who are available to do small technical jobs in direct consultation with the professional staff member concerned. Large or unusual jobs are handled by the Naval Gun Factory, or by contract with nearby commercial shops. The system which we use has been evolved by the NOL management over a period of years and seems to be well suited to the objective of providing expeditious service to the project worker.

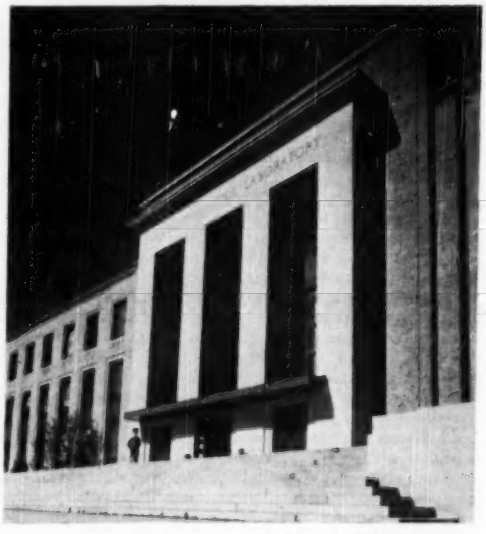
We give much thought at our laboratory to the proper ratio of supporting personnel to our direct project workers. To a first approximation the output of the laboratory will be proportional to the number of direct project workers. However, if these project workers are supplied with insufficient help in the way of technical assistants, artisans, clerical personnel, supply and stockroom operators, draftsmen, library service, or housekeeping help, the effectiveness of the individual falls off and the total number of project workers ceases to be a direct indication of output. By a fairly careful study, which has been intensified over the past year, we have reduced the number of supporting personnel to where it amounts to a little more than two per project worker, and for our present operation this seems to be about right. However, the ratio is an important index and requires constant vigilance to maintain it at the optimum for economical operation.

We are currently carrying on a campaign to simplify our accounting procedures in the hope that we may be able to make available to the project leader all the facilities, materials, and services he may need to carry out his work, and that these can be reasonably accurately indexed in dollar value so that a lump sum of dollars assigned to a particular project or task will enable the leader to use his own individual judgment as to how the effort can best be distributed among technical talent, supporting talent, materials, and services. We feel that by this means we have the best assurance of over-all economical operation, with a minimum of arbitrary control and a maximum availability of all the tools needed.

CONCLUSION

The efforts of the laboratory management would be of no avail if its sponsor did not have full appreciation of what is required to do effective research and development, and did not regard as important the function of establishments such as NOL in the peacetime progress of the Navy. Fortunately, in the management of the Bureau of Ordnance, we have enjoyed a deep comprehension of what is involved in the successful operation of our laboratory. In the evolution of our establishment and that of the Naval Ordnance Test Station at Inyokern, Calif., this Bureau has shown strong leadership in providing the conditions necessary for effective operation.

As the Navy and the Department of Defense adjust their operations toward the specific needs of these and similar establishments, we may expect a continued and steady improvement in performance, a steady growth in the stature of the men who staff these institutions, and an increasingly strong and valued series of bastions in the defense which we must forge if we are to maintain the integrity of the United States, and to preserve for our children the American way of life.



Naval Ordnance Laboratory Photo

ENTRANCE TO THE ADMINISTRATION BUILDING OF THE NEW NAVAL ORDNANCE LABORATORY LOCATED AT WHITE OAK, MARYLAND, JUST NORTH OF WASHINGTON, D. C.

POWDER METALLURGY

A Mid-Century Review and Preview

By PAUL SCHWARZKOPF

PRESIDENT, AMERICAN ELECTRO METAL CORPORATION, YONKERS, N. Y.

EARLY WORK IN POWDER METALLURGY

Of all those writing mid-century reviews, the physicist is in the best position. For the physicist, the year 1900 really represents the beginning of a new era. In 1900 Planck revealed his quantum theory. Also, it was particularly important for the metal physicist. That same year Drude first introduced the concept of free valence electrons and thus laid the foundation for the modern electron theory of metals.

The position of the reviewing powder metallurgist is almost as fortunate as that of the physicist, provided he ascribes only historical importance to the iron powder-metallurgical implements of the old Egyptians and other ancient colleagues of ours, to the platinum of the Incas, and also to the classical experiments of Wollaston. Since this seems justified, modern powder metallurgy may be considered a child of the twentieth century. It was born in 1903, when Just and Hanemann introduced tungsten as material for filaments for electric bulbs. These brittle filaments and similar ones made from molybdenum, used as hooks in these bulbs, were prepared by sintering extruded mixtures of metal powders with organic binders.

When, about 1910, the first publication of the manufacture of a ductile wire from tungsten, produced by normal wire-drawing techniques, appeared, I was already around, and since then I have been continuously active in powder-metallurgical research and production. I have tried my hand in practically all branches of our art, remembering quite distinctly what we learned at each stage and then utilizing this experience to enter and to conquer subsequent stages. This memory might be helpful in predicting to what extent the knowledge accumulated during the first round will act as a decisive and rate-determining factor in the second, that is, in the solution of the problems that we are facing now.

The work required for the development of satisfactory tungsten and molybdenum products needed by the incandescent-lamp industry and later by the electronic-tube industry was a good training for the young powder metallurgist. He not only learned how to prepare, evaluate, and process metal powders, he also observed and systematically studied the effects of powder characteristics, compacting conditions, sintering time and sintering temperature upon microstructure and mechanical properties, and from these observations he was able to contribute to the theories of recovery, recrystallization, and grain growth.

Prominent among the problems encountered by the manufacturer of electric bulbs was that of "sagging" of his filaments. After recrystallization and grain growth had taken place during service, there were at least some grain boundaries going all the way across the filament which resulted in boundary flow and sagging. This rather serious difficulty was overcome by the addition of agents that either retarded recrystallization and grain growth, or promoted an oriented structure. Through these changes in crystallization, the development of grain boundaries, going all the way across the filament, was counteracted and special overlapping structures were produced which prevented the occurrence of sagging.

All that the young powder metallurgist had learned about things like powder treatment and sintering conditions, he could utilize immediately when he turned from refractory metals to other metallic materials. The knowledge he gained in solving the sagging problem was too specific to find immediate application in other fields. But I believe that this special experience may come in very handy in the near future.

APPLICATION IN HIGH-MELTING REFRACTORY METALS

The high-melting refractory metals are "naturals" for all applications requiring high strength at elevated temperatures. Molybdenum takes the spotlight for these uses. The United States and Canada possess immense deposits of molybdenum ores. Molybdenum is readily workable and machinable and can of late—by coatings which protect it from oxidation and corrosion—be made suitable for applications which utilize its tremendous strength at higher temperatures. Of course for all these uses the operating temperature must be well below the range at which recrystallization indicates high atomic mobility. This means that in the case of pure molybdenum—in the purity degrees obtainable today—the operating temperature should not markedly exceed 900 C or about 1650 F. That is quite high, and a long life of parts at this temperature under high stresses means marked progress.

The jet and rocket engineer is already dreaming of higher temperatures, and powder metallurgy—always eager when requirements are extreme—is trying to keep step with him. It is here where the sagging problem may enter the situation. There can be no doubt that sagging, i.e., flow in crystal boundaries, is related to creep, and agents preventing sagging in filaments may very well also suppress creep in parts such as gas-turbine buckets. However, it must also be kept in mind that small amounts of certain impurities influence properties of molybdenum to a very high degree. In experiments with cast molybdenum, Parke and Ham (1)[1] found that even differences in oxygen contents in the order of 0.0025 per cent are of tremendous importance. It is therefore possible that control of purity, that is, the exclusion of the last traces of elements such as oxygen from the grain boundaries, supplemented by the addition of agents which promote controlled crystallization, are imperative in attempts to increase the operating temperature of molybdenum parts. A series of observations also indicates that one of the properties of molybdenum which still restrict the range of its possible uses—its cold-brittleness—will turn out not to be a property of the moly crystals, and therefore can be eliminated.

Sixth Annual Medal Lecture sponsored by the Powder Metallurgy Laboratory, Stevens Institute of Technology, Hoboken, N. J.

NOTE: A medal is awarded annually by the President and Trustees of Stevens Institute of Technology for outstanding achievement in the field of Powder Metallurgy.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

THE COMPACTION PROCESS

The work with molybdenum and tungsten has been the basic training for the powder metallurgist. In so far as subjects such as the control of powder characteristics were concerned, the young scholar was almost ready for graduation. But there were other subjects. Let us take the compaction process. It must be considered that in the manufacture of tungsten and molybdenum products, the powders were pressed to simple bar shapes only. It was much later, in the production of structural iron and steel parts, that we really learned to press complicated, intricate shapes. Furthermore, we still had to explore techniques such as sintering in the presence of a liquid phase and to learn more about the process of infiltration. Both these techniques were utilized as early as the second decade for the production of composite contact materials which combined the wear and heat resistance of the refractory metals and the high conductivity of lower-melting ones, such as silver and copper. The knowledge of the involved mechanisms, at that time, was rather limited. When the powder metallurgist, for example, encountered a system where infiltration did not work, such as cemented carbides, he blamed the system and not his technique.

Recently, the infiltration technique found what is probably its most important practical application in the field of ferrous structural parts. During this development, it came about that the course taken in the second decade had been one for beginners only. Today we know how to infiltrate systems which previously could not be treated by this technique. More of this will be explained later in the paper.

DEVELOPMENT OF CEMENTED CARBIDES

The third decade brought the development of the modern cemented carbides. It started in Germany, when a substitute was needed for the diamond drawing dies for the wire-producing industry. The carbides of the refractory metals were found to have the required hardness and wear resistance. H. Lohmann was the first who produced drawing dies from tungsten carbide by melting and casting. That was in 1914, already in the second decade. The cast dies were typical "ersatz" products. Satisfactory control of composition and quality could not be achieved. Lohmann himself tried to overcome his difficulties by replacing casting with sintering of pressed bodies from tungsten-carbide powder. The improvement was not marked and—as already mentioned—attempts to apply the infiltration technique for the introduction of a binder material also failed.

The problem of consolidating carbides was solved finally when, in the early 1920's, Schroeter developed his method of sintering in the presence of a liquid binder metal phase. Tungsten carbide, cemented according to Schroeter with various amounts of cobalt, proved highly satisfactory as material for wire-drawing dies, wear-resistant parts, and as cutting tools, e.g., for gray cast iron.

The cemented tungsten carbides now on the market are practically identical with the material introduced by Schroeter. The advent of his cemented tungsten-carbide tools initiated a revolution of the machining technique. However, the applicability was still limited to the machining of rather brittle materials, such as the gray cast iron mentioned, which upon machining yield short, crumbly chips. For tougher and stronger materials, particularly steel, which give long chips, the tungsten carbide-cobalt materials, as well as tantalum-carbide materials containing also only one carbide, were not satisfactory. For these most important applications it was necessary to develop other cemented carbides. We found that solid solutions—mixed crystals—of two or more carbides were necessary to meet the requirements for cutting long-chipping materials.

Since 1929, WC-TiC-Co and similar double or triple-carbide tools have been used successfully for the high-speed machining of steel and similar tough materials. The part played by the new tools in the armament race at the beginning of the last war is generally recognized, and certainly one of the most striking testimonials that can be given the achievement of powder metallurgy.

Today we have an ample supply of data on the crystal structures of the compounds involved, on the mutual solubilities of carbides, and on the sintering mechanics. Thanks to the work of men like Comstock, Norton, and Redmond in this country, Brownlee, Metcalfe, and Raine in England, Kieffer and Nowotny in Austria, Dawihl in Germany, and Meerson and Umanski in Russia, to name only a few, these are well-established facts today.

Not many of these data were available when I started my work with solid solutions of carbides. Fortunately, enough was known to center the interest on systems containing TiC as additional carbide, and it is rather satisfying to note that the multiple-carbide tools used today are essentially identical with those made twenty years ago. Since, however, materials such as WC-TiC-Co compositions contain excessive amounts of scarce elements, which are found only at a few points of the earth's surface, my last statement is an admission of failure. We certainly tried hard to replace tungsten and cobalt with more readily available materials. We did not succeed. The substitutes developed during the war in Germany—mostly solid solutions of titanium carbide with carbides of metals such as vanadium—had rather limited applications. As previously stated, it is a failure, but in a way this failure is satisfying.

The question I should like to raise at this point is whether or not we can expect, in the years to come, progress in the cemented-carbide field—progress going beyond the developments which are associated with the name of McKenna, and represent the first practical application of cemented carbides in the high-temperature field. I firmly believe that my optimistic view in this respect is more than just wishful thinking. To support this view let us consider some aspects of the theory involved.

THEORETICAL CONSIDERATIONS

The carbides we are interested in are all compounds of carbon with metals of the so-called transition groups of the periodic system. If the ratio of the atomic diameter of the C atom to that of the metal atom is less than about 0.59, then the carbide represents, according to Hägg, an ideal interstitial alloy. The metal atoms are in a simple close-packed arrangement and the C atoms fill the interstices of the lattice. In mixed crystals of different carbides, we have the interesting case of an alloy which is substitutional and interstitial at the same time. The metal atoms, taken by themselves, form a close-packed substitutional alloy with the interstices filled with the carbon atoms. But this well-established structure is only one side of the picture. It shows how the atoms are arranged with respect to each other, but it does not show how the atoms are bonded together. We became accustomed to the concept that the close-packed metal atoms in interstitial phases are held together by metallic bonds. But there seems to be no general consensus of opinion.

To give an example, in a recent paper (2), I found to my surprise that carbides were being classified as ceramics. The author clearly stated what he meant when he referred to ceramics: "Any material that is neither organic nor metallic." I do not know what ceramists think of this definition. I have no objection to it, but I believe the statement is meaningless without giving a definition of a metal. If, e.g., the positive temperature coefficient of electrical resistivity is taken as a criterion, then our carbides represent typical examples for metals. We cannot deny the close relationship between ce-

ramics and powder metallurgy, and we gratefully acknowledge that powder metallurgy learned much from the older techniques of the ceramic industry. More than that—we are prepared to go on learning from the ceramist wherever we can, and we shall acknowledge this. But the ceramist is mistaken when he thinks he can claim the carbides as a fee for his teaching.

In any case, the low thermal and electrical resistivities and the positive temperature coefficient are characteristic properties of the carbides. The resistivity of some interstitial alloys is even lower than that of their transition-metal components. This is interesting from the viewpoint of the electron theory of metals. The resistivity of all transition metals is comparatively high, and this is explained by the electron theory of metals as being due to the high density of quantum states in the only partially filled d-bands of the transition metals. From this viewpoint, it could be assumed that electrons from the interstitial carbon atoms lessen the number of available d-states, and thus increase the conductivity of the carbides above the value of the pure transition metals.

These arguments represent a strong support for the assumption of metallic bonds in interstitial phases. However, the problem is more complex than indicated so far. Following Pauling and Rundle, it seems necessary to accept—in addition to metallic bonds—the presence of directed bonds in interstitial carbides. Pauling's theory seems especially fitted for application to interstitial compounds, and I am afraid we shall have to get used to half bonds and similar concepts of his theory. The metal physicist cannot and does not overlook successes of Pauling's chemical theory of the metallic bond, such as the interpretation of the magnetic characteristics and high melting points of the transition metals. The physical chemist, on the other hand, should not overlook that Pauling, so far, has not been able to extend his theory to semiconductors. Sooner or later, the physical metallurgist and the physical chemist will have to find a common language. Their closest approach to each other, so far, is to be found in the theory of the transition metals, and it may very well be that the final union will be accomplished in the theory of interstitial phases.

THE PRACTICAL APPROACH

The practical man has not the time to wait for the final theory. He has to go ahead on the basis of the fragments so far supplied, and he might be able to do so. I indicated how little data on crystal structures were available when we succeeded in developing the modern carbide tools. So it may well turn out that the little knowledge we have today of the electron and bond structure will point correctly to the direction we have to follow in our present and future work.

There are reasons to expect that interstitial carbides are particularly promising in so far as high-strength requirements at high temperatures are concerned. The high melting points and the high moduli of rigidity are among the criteria pointing in this direction. I am speaking now of pure interstitial carbides and solid solutions thereof, and not of the standard cemented-carbide materials. Standard cementing methods which are satisfactory for the manufacture of tools and wear-resistant parts reduce the hot strength. To utilize fully the inherent high-temperature strength of the carbides, it will be necessary to design new cementing procedures. There are reasons to believe that this can be done. But in so far as applications such as the use as gas-turbine buckets are concerned, this would represent only a partial solution. If we aim at operating temperatures markedly in excess of today's, we cannot dare to expect that carbides will meet with the second main requirement of high-temperature materials, namely, that of resistance to corrosion and, particularly, of resistance to oxidation. It would be necessary to provide the carbide materials—like the refractory metals—with corrosion-resisting coatings.

There is no question but that it is preferable to use materials meeting both requirements: that of strength and that of oxidation resistance. The hot strength of interstitial carbides is, no doubt, closely connected with their structure, that is to say, with the arrangement of the atoms as well as with the nature of the bonds between these atoms. Substances of a similar structure therefore could be expected to exhibit an equivalent hot strength. It appeared worth our while to scrutinize the list of such substances for some which might, in addition to hot strength, also be of high corrosion resistance.

We found that the most promising compounds were commercially not available, and thus it became necessary for the powder metallurgist to enter the field of preparative inorganic chemistry. This proved a successful detour. I am glad that I am permitted to mention a recent Navy release which revealed that a new material, based upon zirconium boride, withstood higher temperatures on the test stand than any other material. This new product has been developed following the ideas mentioned.

All this is a beginning. It is too early to predict the field of application for which the new material will prove most advantageous, but it is at least possible that these fields will include—besides high-temperature uses which are in the foreground—also a new group of machining tools.

INTERMETALLIC COMPOUNDS

There is another field in which the powder metallurgist has come in close contact with intermetallic compounds. In the search for coatings which would make refractory metals resistant to oxidation at high temperatures, it was found that in several instances the formation of intermetallic phases, such as silicides, is essential for effective protection. One of the next steps in research will be the study of these intermetallic phases. Some of these phases may be electron compounds, others may be co-valency compounds, and still others even ionic compounds. This is virgin territory. The phase diagrams involved will have to be established, and the structure of the intermetallics must be correlated with the properties. It may very well be that some of these intermetallics can be bonded by methods of powder metallurgy and would represent in this form satisfactory high-temperature materials.

So far, theory is not offering much help in this line. Since the systems under consideration contain metals of the transition group, it can be expected that any structure which might be established experimentally will be explained by the theory. The Pauling theory will do that by postulating suitable resonance effects, and the electron theory of metals will also be able to offer an interpretation since, according to this theory, transition metals may have different valencies in different combinations so that it will not be difficult to postulate a valency in agreement with the experimental results. Unfortunately, the man of practice is less interested in such explanations than he is in predictions.

It should be admitted that in this connection the term intermetallics is used somewhat loosely. We do not know whether all the compounds under study are actually metallic in character. It may very well be that some of these compounds must be classified as ceramics.

DEVELOPMENT OF FERRITE MATERIALS

Speaking of ceramics, we should mention here a very important development in the magnetic field, which involved the use of powder-metallurgical techniques, namely, the development of the ferrite materials. With the development of these soft magnetic materials of high electrical resistivity, Snoek succeeded in practically eliminating eddy losses in high-

frequency applications. This problem could not be solved with pure-metal powders. If the ceramist claims these oxides, it is hard to find a logical basis for an objection. In any case, techniques of powder metallurgy permit us to handle the oxide powders and to produce ferrite materials.

Sintered mixtures of metal powders with powders of oxides or other ceramic materials have recently attracted the interest of the powder metallurgist as well as that of the ceramist. Terms such as "ceramels," "cermets," and "cermets" have been suggested for this class of products. Some of the workers in this field think in terms of electrical applications. Such mixtures also have been tested, without appreciable success, for tool materials. Most important, however, appears the potential use of these materials for high-temperature purposes. In applications such as turbine blades, ceramic oxides usually fail on account of their low resistance to thermal shock. It very well may be possible that the incorporation of suitable metals may impart to these products the required thermal-shock resistance.

When one sinters a mixture of, say, aluminum oxide and iron powders, he is at liberty to consider the sintered mixture as iron-bound aluminum oxide. This point of view clearly demonstrates the close relationship between oxide-metal combinations, that is, cemented oxides, and our cemented carbides. This is a problem where the ceramist can utilize the experience gained in the development of cemented-carbide materials; in other words, where the ceramist can learn from the powder metallurgist.

MANUFACTURING COMPOSITE CONTACT MATERIALS BY INFILTRATION

Another important development in the chronology of the powder metallurgist is that of the composite contact materials.

Manufacturing composite contact materials by infiltration, we had first to prepare porous skeletons of the high-melting components. At that time we learned the fundamentals of how to prepare parts of controlled porosity. The powder metallurgist began his advanced course in this art at the beginning of the fourth decade in the mass production of porous bronze bearings, which today is one of the most important phases of our industry.

We became skillful in the art of producing parts of closely controlled porosity through achievements such as the mass production of the porous nickel cup which was the safety device of the proximity fuse. This miraculous fuse played a decisive part in Britain's defense against the V-bombs, in the Battle of the Belgian Bulge, and in the defeat of the Japanese suicide bombers, and thus contributed largely toward shortening the war. It has been claimed repeatedly that the proximity fuse surpassed in practical importance all other wartime inventions, and this claim may very well be justified.

Further developments in the field of porous parts which must be mentioned, since their principle may be useful in future applications, are the iron projectile-driving bands—a German war development—and the aircraft deicing equipment, a British development.

An interesting new field for porous powder-metallurgical parts had been opened by the so-called sweat or transpiration-cooling method as developed by Duwez in the Jet Propulsion Laboratory of the California Institute of Technology (3). Duwez is forcing a cooling liquid through porous metal parts in a direction opposite to that of the heat flow. This procedure permits very marked increases in operating temperatures and may be expected to find wide and important uses.

So far, this review has been limited essentially to so-called noncompetitive products, that is to say, products which cannot be manufactured by any method other than powder metallurgy. This is true for the refractory metals which have a melting point too high for other processing methods; it is also true for composite contact materials, for cemented carbides, and for parts of controlled porosity.

POWDER METALLURGY ENTERS THE COMPETITIVE FIELD

At the beginning of the 1940 decade, the powder metallurgist had learned enough to try his hand also in the competitive field. His technique was advanced enough to be employed in the production of parts—especially iron and steel parts—which could be and, in most cases, were previously manufactured by standard metallurgical procedures. In order to be able to compete, the products of powder metallurgy had to be less expensive than the standard cast materials. The powder metallurgist had to find the most economical production methods. The classical investigation of Sauerwald and his co-workers, published in the 1920's, supplied valuable data revealing the effects of compacting and sintering conditions on the characteristics of iron compacts.

In the early 1930's, the attempts of the German industry to find a use for carbonyl iron had further increased our knowledge. But these were experiments carried out with iron powders of high purity under laboratory conditions. It was a long way from the laboratory to mass production based on commercial powders. The price of these commercial powders was—and still is—high as compared with the raw material of our competitors. We have to overcome this handicap, and in order to do so, we must make full use of the fact that powder metallurgy permits us to make parts in final shapes and thus to save cost of machining. The more complicated a part, the higher are the savings.

The powder metallurgist thus had to become a master in the art of compacting powders to complicated shapes. The progress made in this direction during the last years is outstanding. As an example, Fig. 1 shows a compressor blade for jet engines that is now being mass-produced by powder metallurgy based on developments carried out by my company in collaboration with Thompson Products (4). The tolerances we had to maintain in this case were extremely close. The differences in thickness between the thin trailing edge and the root will be noted, as well as the fact that the blade is twisted.

We had to go a long way until we were able to meet the strength requirements of the compressor blade. For help in

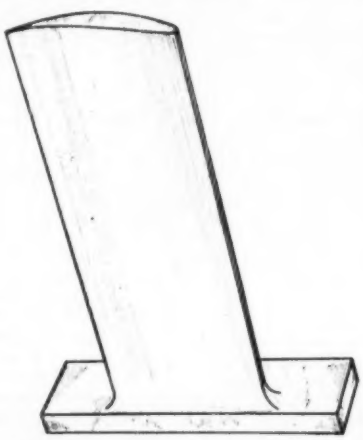


FIG. 1 COMPRESSOR BLADE FOR JET ENGINE

future developments in the competitive field, it may be permissible to describe more in detail this phase of our work (4, 5, 6).

HOW COMPETITIVE PARTS ARE PRODUCED

In principle it is possible to produce sintered parts having the same strength as cast and wrought materials of corresponding composition. All we have to do is to eliminate all residual porosity. As long as we have pores, we have notch effects and inferior strength. This must be admitted. For a large number of purposes, this inferior strength is still far in excess of the requirements. However, for high strength, we have to get rid of that residual porosity. As soon as we succeed, we have powder-metallurgical parts that are as strong as the corresponding cast and wrought materials. Furthermore, owing to the advantage of easier control of purity and boundary conditions, these parts may be even stronger.

Practically pore-free bodies may be produced by hot-pressing or repeated cycles of compacting at high pressures and sintering at elevated temperatures. But these procedures are too expensive for products in a competitive field. There is reason to expect that future developments will lead to economical hot-pressing techniques, but, so far, such techniques are not available.

It was the experience in the production of composite contact materials that indicated another, more economical, way to arrive at a pore-free condition; that means sintered parts of high strength. Sintered iron or steel skeletons were prepared having a porosity of about 15 per cent by volume, and the pores were filled by infiltrating a liquid copper alloy. Table 1

TABLE 1 EFFECT OF HEAT-TREATMENT ON SOME MECHANICAL PROPERTIES OF INFILTRATED IRON AND STEEL*

(The ferrous skeletons of all specimens were pressed and sintered to 85 per cent density. Complete infiltration of all specimens then left them virtually free from residual pores)

		As infiltrated[b]	Solution-heat-treated[c]	Precipitation-hardened[d]
Fe-Cu[e]	Yield strength, psi	62,200	61,300	75,400
	Tensile strength, psi	67,500	71,700	81,900
	Elongation, %	3.3	6	3
	Area reduction, %	3.3	6.6	3.5
	Rockwell B	95.5	82	92.5
Fe-Cu-Mn[e]	Yield strength, psi	89,500	70,500	87,100
	Tensile strength, psi	91,800	84,600	93,500
	Elongation, %	1.3	5.3	2.6
	Area reduction, %	0.82	7.0	2.4
	Rockwell B	96.5	89	91.5
Fe-Cu-C[f]	Yield strength, psi	72,900	71,300	78,500
	Tensile strength, psi	76,100	76,700	79,500
	Elongation, %	1.6	3.0	2.3
	Area reduction, %	2.1	6.0	3.8
	Rockwell B	88	101	89.5
Fe-Cu-C-Mn[e,f]	Yield strength, psi	95,200	88,500	93,900
	Tensile strength, psi	95,200	92,900	94,700
	Elongation, %	1.3	2	1
	Area reduction, %	0.82	1.63	0.82
	Rockwell B	96	94.5	91.5

[a] After pressing and sintering to 85 per cent density, specimens were infiltrated with a mixture containing 98 per cent electrolytic copper and 2 per cent iron.

[b] Infiltrated at 2125 F for one hour.

[c] The infiltrated specimens were heated to 1300 F for one-half hour and then to 1600 F for one-half hour and finally quenched in oil.

[d] After solution heat-treatment, the specimens were precipitation-hardened by holding at 930 F for one hour.

[e] The infiltrant was a mixture of 90 per cent copper, 2 per cent iron, and 8 per cent manganese.

[f] Graphic (0.25 per cent) was added to the iron powder prior to compaction.

* Courtesy of *Metal Progress*, January, 1950 (6).

shows the strength values which we were able to obtain in mass-production runs.

In order to reach the remarkable tensile properties listed in the last column of the table, it was necessary to design a special heat-treatment to strengthen the ferrous as well as the cuprous phase by precipitation-hardening.

MECHANISM OF INFILTRATION PROCESS

During this work we learned much about the mechanism of the infiltration process. Today we consider this procedure as a sequence of the following steps (6):

1 Sintering in the absence of a liquid phase.
2 Infiltration.
3 Sintering in the presence of a liquid phase.

The success of the infiltration technique is, to a large extent, due to the fact that it permits the combination of the advantage of sintering in the absence and sintering in the presence of a liquid phase. The accompanying schematic drawings may serve to illustrate this point.

During sintering of iron in the absence of a liquid phase, the pores tend to spheroidize, as shown in Fig. 2. Spheroidization of pores is accompanied by the establishment of large contact areas. It will be understood that a structure approaching that shown in Fig. 2 will be observable only after long sintering at high temperatures. However, the tendency to spheroidization and thus toward establishment of large contact areas will always be there as long as sintering takes place in the absence of a liquid phase.

When we sinter ferrous skeletons in the presence of a liquid cuprous phase, on the other hand, we observe a spheroidization of the ferrous particles as schematically shown in Fig. 3. This spheroidization counteracts the establishment of large contact areas between the iron particles. The larger the contact areas, the stronger the bonding. From this viewpoint, sintering without a liquid phase would seem superior; but there are other factors to be considered. Aside from the practical elimination of residual porosity, the liquid phase brings additional advantages. When we sinter a homogeneous metal-powder compact below the melting point of the metal, the rearrangement of the atoms takes place by a bulk-diffusion or viscous-flow mechanism. When we sinter an iron skeleton in the presence of a liquid copper alloy, atomic rearrangement may also be effected by a mechanism of solution and reprecipitation. No calculations are available, but it may very well be that this mechanism is more effective than that afore-mentioned.

In any case, there is no doubt that both processes, sintering in the absence and sintering in the presence of a liquid phase, have their distinct advantages. The advantage of the first process is the establishment of large contact areas. When we now sinter first without and subsequently with a liquid phase, we can assume that the contact areas established during the first step will not be disrupted by the subsequent introduction of a liquid. A structure as indicated in Fig. 4 will result. The infiltration technique thus offers a possibility of combining the beneficial establishment of large iron-to-iron contact areas with the well-known advantages of sintering in the presence of a liquid phase.

The new application of the infiltration technique permits the economical production of high-strength structural parts by powder metallurgy. Further expansion in this direction is imperative.

CONCLUSION

In outline, this is the course of developments which led from the manufacture of ductile tungsten and molybdenum to the production of composite contact materials, cemented carbides,

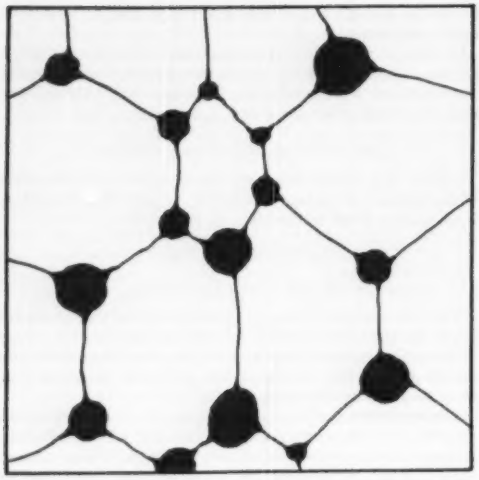


FIG. 2 PORES SHOWING SPHEROIDIZATION IN ABSENCE OF LIQUID PHASE

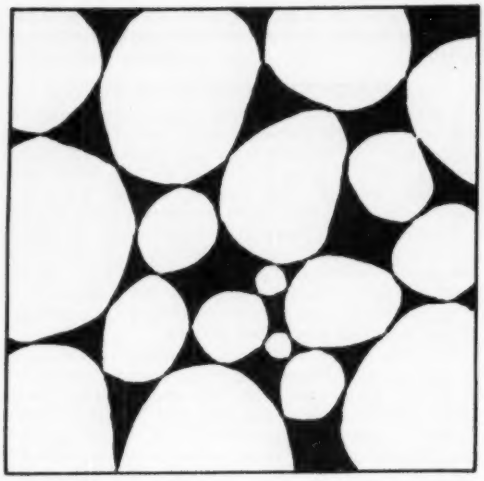


FIG. 3 SPHEROIDIZATION OF FERROUS PARTICLES IN PRESENCE OF LIQUID CUPROUS PHASE

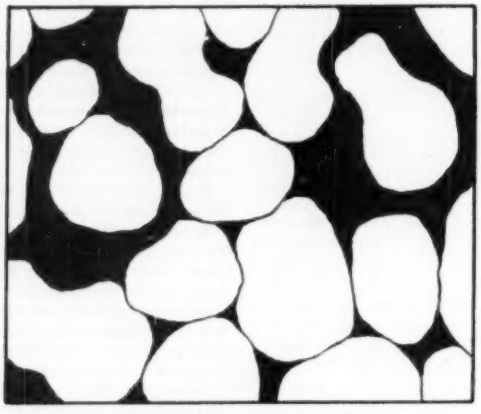


FIG. 4 STRUCTURE RESULTING FROM FIRST SINTERING WITHOUT AND THEN WITH A LIQUID PHASE

porous parts, and high-strength structural materials. The accomplishments made in this art appear rather impressive.

The potentialities of powder metallurgy are far from being utilized fully. As we used the experience gained in, say, the 1920's, for our work in the subsequent decade, so we shall be able to use the experience gained in the first half of the century for the work to be done in the second half.

I have expressed my belief that, with the aid of powder metallurgy, it will be possible to solve one of the most urgent engineering problems of our day, that is, the development of materials exhibiting satisfactory strength and corrosion resistance at extremely high temperatures. I fully realize the risk involved in predictions of things to come, but I sincerely believe the foundations laid by the work of the powder metallurgist in the past half century are sound enough to justify the optimism expressed in this preview.

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SELF-UNLOADING SHIP MAKES POSSIBLE DELIVERY OF CARGO TO ANY WATERFRONT POINT WITHOUT USE OF SHORE UNLOADING EQUIPMENT

Engineering the BELT-CONVEYER INSTALLATION

By HAROLD VON THADEN

VICE-PRESIDENT, HEWITT-ROBINS, INC., NEW YORK, N. Y.

THE belt-conveyer industry, a little more than 50 years old, is one of the main forces of progress behind the construction, mining, manufacturing, and transportation fields. In sales volume, it has grown to an estimated $200,000,000 a year.

Belt conveyers have spanned rivers, tunneled through mountains, and reached out under the sea. They have been used to undermine buildings needing foundation repairs.

MINING INSTALLATIONS

As long as 25 years ago a large coal company at Brownsville, Pa., replaced an underground railroad of more than 5½ miles with a belt-conveyer system. Today this system regularly delivers upward of 1800 tons of coal an hour from the work facings, through a mountain to waiting barges on the Monongahela River. A similar installation, near Morgantown, W. Va., is remarkable for its single conveyer with 10,900-ft centers.

Conveyer installations in many other mines have helped make possible the fact that today, with a quarter of a million fewer miners than in 1920, we can mine 51,000,000 more tons of coal a year. Installation of some 1000 miles of belt conveyers in our mines (with 4000 miles to go for complete conveyerization) has enabled us to turn out six tons of coal per man-day, as against a little more than a ton per man-day in England, and less than a ton a day per capita in Germany and France.

The future of the coal mines seems to point toward even more mechanization, particularly if the normal demand for coal keeps to the trend of the past years.

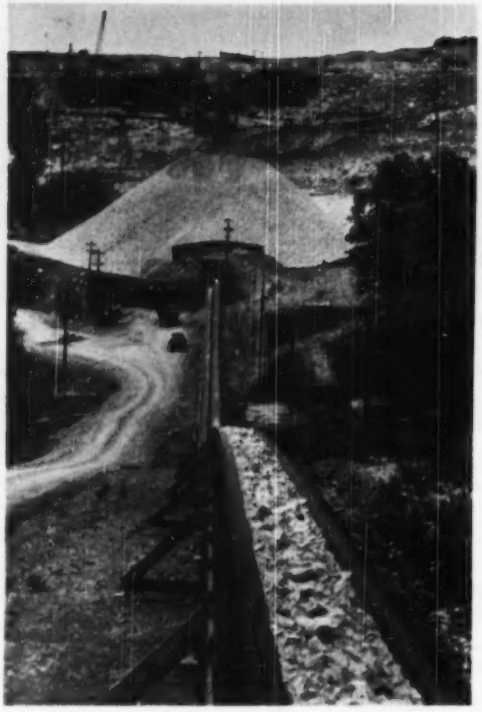
The steel industry also depends heavily upon conveyer systems. From the iron and coal mines and the limestone quarries, to the transportation facilities for these raw materials, to the by-product coke ovens, to the handling of hot steel in the mills themselves, conveyers save millions of dollars and help make possible our vast annual steel tonnages.

To replace antiquated bin and bunker mixing and blending methods in the steel industry, engineers have developed new conveying systems for blending high and low-grade iron ores to produce more efficient uniformity of furnace mix, and systems for blending coals of high and low volatility to produce a more uniform mixture of these coals for the manufacture of metallurgical coke. This proper blending of ores produces a regularity of product going to the furnaces and the job of altering the basicity of mixture going to the furnace is reduced because proper blending minimizes ore fluctuation. Since the introduction of blending systems for ores and coals, blast-furnace results have improved greatly, resulting in a 5 per cent increase of output. Metallurgical coke consumption has decreased about 300 lb of coke per ton of iron produced from the furnace. In addition, iron quality is improved and is of great regularity.

SELF-UNLOADING SHIPS

For the shipping and marine industry the conveyer industry has developed self-unloading ships that can discharge 10,000

Contributed by the Materials Handling Division and presented at the Annual Meeting, New York, N. Y., November 27–December 2, 1949, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Condensed.



LIMESTONE FROM QUARRY AT FLIPPIN, ARK., PASSES THROUGH TWO CRUSHERS; IS DUMPED INTO A 20,000-TON SURGE PILE FROM WHERE IT IS PICKED UP BY THE BELT CONVEYER FOR THE SEVEN-MILE LIFT, LONGEST IN OPERATION TODAY, TO THE BULL SHOALS DAM CONSTRUCTION SITE IN WHITE RIVER

tons of bulk cargo and neatly pile it ashore in about five hours, with as few as three men handling the conveyers and, if dock space permits, without assistance of any shore-based equipment.

These ships need not be built specifically for self-unloading. Many successful conversions have been made of cargo ships that have been operated for as long as 30 years by old-fashioned methods of unloading. In general, a self-unloader conversion consists of hoppering the hold to serve two belt conveyers symmetrically arranged on either side of the ship's centerline. These conveyers deliver to an inclined-plane conveyer which carries the cargo to the deck. At this point it is discharged to a boom conveyer, the boom of which is pivoted to the deck and carried by an "A" frame structure. Some of these booms are as long as 275 ft. It may be swung over the side of the vessel and topped up to any desired angle, within certain limits. The boom conveyer discharges the cargo on the dock, or if desired, into railroad cars or other ships.

Conveyerized shore installations also have materially aided the shipper in keeping down his bulk cargo handling costs. From the island of Spitsbergen, within a few hundred miles of the North Pole, to the coast of Southern Chile, conveyers are mechanically loading ships with coal, iron ore, manganese, limestone, and other bulk materials at rates of from 350 tons an hour to 10,000 tons an hour.

In one instance, a system of movable gantries on the dock that suspend elevators feeding to belt conveyers has so drastically cut down the turn-around time of a ship transporting sugar, that she can make three round trips in the time formerly required to make two.

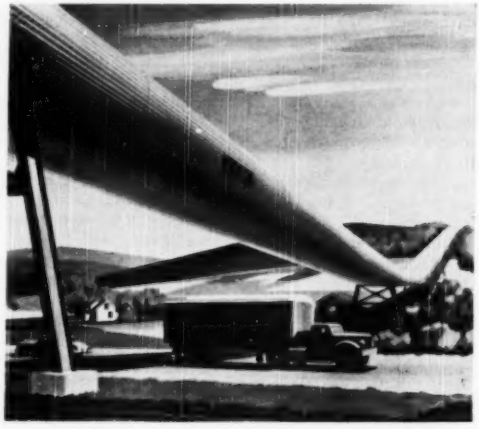
A major problem confronting the maritime industry today is the cost of the time spent in stowing boxed cargoes; about 25 per cent of the total man-hours involved in loading is consumed. Three of America's newest and fastest round-the-world passenger-cargo ships, now being built for the American President Lines, indicate the way to solve the problem. By means of a system of elevators and conveyers, 1500 pieces of boxed cargo, of a maximum weight of 250 lb, can be loaded per hour. The boxed cargo is brought aboard through side loading hatches where portable conveyers carry it to the elevators that automatically discharge it to any of the lower cargo decks. In unloading the ship, the same flexible system saves a similar amount of time and money by reversing the operation.

CONVEYERS IN DAM CONSTRUCTION

At Grand Coulee Dam in Washington, engineers were called upon to transport the construction aggregates from the preparation plant across the Columbia River. They solved the problem by running a straight-line belt conveyer, composed of flights averaging 1000 ft in length. Taking land contours as they came, the conveyer carried 1000 tons an hour and finally crossed the river on a low-cost suspension bridge of about 3500-ft span. Another conveyer system removed the principal excavation at a rate of 4000 tons an hour. If this operation had been attempted by truck it would have required a 3-mile-long superhighway, filled with trucks at about 100-ft centers.

At Shasta, on the Sacramento River in California, engineers discovered that not only would the aggregate haulage fill six freight trains a day but many spur lines and sidings would have to be built, making the project too costly for the railroad. The ten-mile belt conveyer set up was able to handle the 12,000,000 tons of aggregate at a cost approximately one third below the railroad.

After these successful and cost-saving experiences, it was natural that the same system be used in construction of the Bull Shoals Dam in Arkansas. Today the seven-mile conveyer—the longest in operation today—is rolling steadily at the job of moving about 4,000,000 tons of aggregates needed to build this hydroelectric-power project.



SKETCH OF PROJECTED 130-MILE RIVERLAKE BELT

CONVEYING DELICATE MATERIALS

The problem of conveying soft and oftentimes delicate bulk materials has been solved in some instances by the adaptation of the "zipper" conveyer belt. To the sides of a regular flat rubber and fabric endless belt, flexible rubber sidewalls have been hinged which can be sealed at the top by a method similar to the zipper fastener. The belt, which is sealed and unsealed automatically, becomes a moving pipe when loaded and can be run around corners and elevated vertically. It has found numerous applications in a variety of specialized industries—a chemical plant where five different chemicals are conveyed without mixing; a plant where fragile unfired ceramic pellets are carried without spillage; a dehydrating plant where cooked vegetables are carried quickly and hygienically; and a food plant where shelled almonds are carried without breakage. This enclosed conveyer elevator, in some cases, has replaced two conventional belt conveyers and a bucket elevator.

UNDERWATER CONVEYERS

Installations of conveyer systems in underwater tunnels include one in Boston, where a conveyer had to carry materials one mile through a tunnel in such a way that an elevated air pressure needed in the tunnel could be maintained and the materials could be continuously carried through an air lock. In another installation on the coast of South America, a belt conveyer operates continuously in a mine tunnel and steals coal from a mile out under the Pacific Ocean.

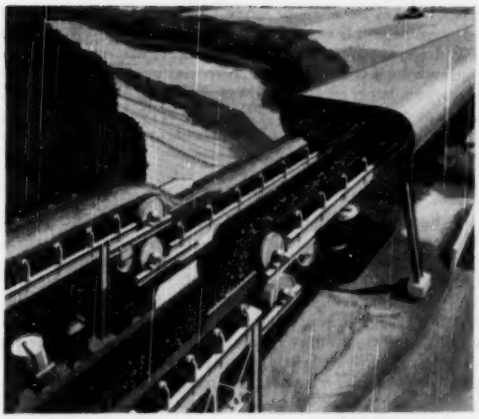
FUTURE CONVEYER INSTALLATIONS

As for the future, many new kinds of machines must be created and many more miles of conveyers must be installed.

For example, with the increased length of passenger trains, why should we have to carry heavy luggage for a distance of two city blocks down the station platform? Why not ride along a moving sidewalk, luggage in front or back of us, free from the discomfort of struggling with baggage?

The day of widespread use of baggage conveyers is here. A major hotel chain already is contemplating luggage conveyers running from street curb to hotel lobby.

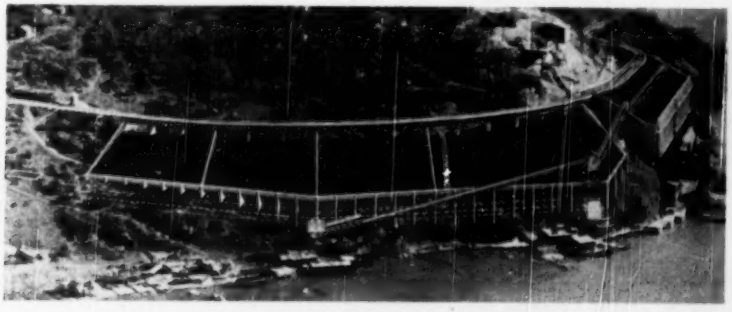
An excellent example of the need for a conveyer system is the subway train in New York City that shuttles crowded passengers from Times Square to Grand Central Station. It is highly probable that in our lifetime we will see the dirty uncomfortable shuttle replaced by a moving sidewalk that will carry passengers quickly and safely between the two terminals. Furthermore, there is no reason why a connecting link could not add the Pennsylvania Station to the circuit.



TYPICAL TRANSFER POINT ON RIVERLAKE CONVEYER IS SHOWN AS LOADS OF COAL OR IRON ORE ARE RELAYED FROM ONE BELT TO ANOTHER

A similar system could relieve the congestion of city traffic, particularly heavy trucks jamming the streets and turning sidewalks into unloading platforms. One remedy, which it is claimed will rid the streets of 25 per cent of the large trucks, is to build large trucking depots at the edges of the central business district. Goods would still have to move from stores to terminals, but they could easily be moved on a public conveyer system. Suspended overhead or running underground, such a system could operate on a charge per tonnage basis, paid for by the users. With such a freight conveyer there would be little need for trucks on the streets.

The movement of both people and vehicles through the streets of large cities is rapidly becoming a problem in materials handling. The time has arrived when the civic development commissions of large cities should have on their staffs a materials-handling engineer, who can devise methods of handling



COMPOSITE DRAWING AND PHOTO OF PROPOSED ENLARGEMENT TO IRON-ORE STORAGE FACILITY AT PORT VITORIA, BRAZIL

[Ore, dumped from train into bins, is fed from bins to underground tunnel conveyers (dotted lines). These in turn feed to three above-ground conveyers which carry ore to bin at far right which discharges into vessels for shipment. Bin at right is presently in place. The other four bins and the above-ground conveyers are drawings of proposed structures.]

people as they move about a city. His experience could solve many traffic problems.

In short, one of the greatest drawbacks of modern transportation systems is the confusion that springs up at terminals when passengers, baggage, and freight move on and off trains, trucks, ships, planes, and buses. The even flow of people and materials has not kept pace with the advances made in speed and efficiency of transportation.

130-MILE BELT CONVEYER

Perhaps the greatest challenge to the industry in the immediate future is the projected 130-mile belt-conveyer system known as the Riverlake. With terminals planned for Lorain, Ohio, on Lake Erie and the Ohio River, and spur lines to Youngstown and Cleveland, the twin-belt system could carry 32,000,000 long tons of iron ore a year south from Lake Erie, and 20,000,000 tons of coal north to the lake. Annual savings of 20 to 45 million dollars, depending on tonnages, are anticipated. The conveyer would cut straight across the countryside, and offer a continuous and dependable means of delivering vital raw materials.

Because of its size and potentialities, the Riverlake "Rubber Railroad" dramatically displays the advantages and economies inherent in all belt-conveyer systems.

For example, on the Riverlake system, a minimum tonnage of 30,000,000 tons a year will represent an estimated average saving of 58 cents a ton over present freight rates. At the maximum capacity for the line—52,000,000 tons a year—the estimated saving will increase to an average of 78 cents a ton.

A belt-conveyer system can effect these savings because of the following:

1 Whether a conveyer is carrying maximum or minimum loads it requires the same minimum equipment and personnel.

2 Its installation, operation, and maintenance costs are lower than any other type of overland common carrier.

3 It can travel in a straight line, following the contours of the land to grades as high as 34 per cent.

4 A light framework is sufficient because the heavy tonnages carried travel in a continuous flow; therefore no costly bridges are needed to span rivers, ravines, highways, or railroads.

5 A belt conveyer can—and usually does—operate continuously without time lost for loading and unloading, for starting and stopping.

ORE-CARRYING BELT CONVEYERS

Because of the possible dwindling of the Mesabi Range's supply of iron ore, two other sources of supply have been investigated. In both plans the belt conveyer is being considered. Should the utilization of low-grade taconite ore be developed, the only feasible means of handling the vast quantities of ore needed is the belt conveyer. Should ore supplies in Labrador, Morocco, and South America be developed further, again the belt conveyer would be indispensable, for in these countries present transportation systems are negligible.

In Labrador, for example, a belt-conveyer system could feed ore to the projected railroad. It could carry certain materials over terrain where no railroad could operate. Conveying systems can make it possible to operate railroads profitably. The same situation applies in Africa and South America. The belt conveyer may be the ultimate means for these relatively undeveloped areas to become prosperous suppliers of raw materials to the world.

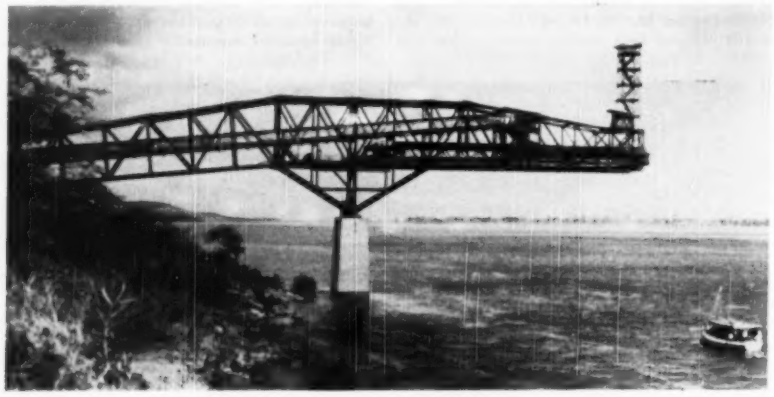
DISTANT FUTURE

Looking further into the future, belts of half their present width and twice their speed doing a more economical job than at present will be developed. Narrower belts will reduce installation costs, take up less space, and by using smaller parts, lower operating expenses.

Better means of applying power are just ahead, so that longer single lengths of belt can be used, costly transfer points eliminated, and single conveyers measured in miles instead of hundreds of feet.

Belt conveyers that turn corners will be difficult but not impossible, and after turning around corners, there remains the problem of climbing higher in the air. A slope conveyer that spirals its way upward about a center axis may be the answer.

Problems like these and others should provide stimulating effects upon the imagination of the materials-handling engineer.



LOADING BRIDGE AT PALUA, VENEZUELA, LOCATED AT THE END OF A HEWITT-ROBINS CONVEYER SYSTEM THAT BRINGS ORE FROM THE RAILROAD IN THE DENSE VENEZUELAN JUNGLES, PROJECTS OVER THE ORINOCO RIVER AND WILL DISCHARGE IRON ORE INTO BARGES

(By an extension, at right, the bridge can reach 600 ft over the water to load craft when the water level is low. Loaded ore will be barged to Puerto de Hierro where it will be unloaded on a conveyer system to huge stockpiles, then reloaded by moving belts into ocean-going vessels for delivery to American blast furnaces.)

ACCIDENT STATISTICS *Can Contribute to* SAFER FLYING

By JESSE W. LANKFORD

CIVIL AERONAUTICS BOARD, WASHINGTON, D. C.

INTRODUCTION

ONE of the grimmer duties of the independent Civil Aeronautics Board is its responsibility in connection with aircraft-accident investigation. It is not always a pleasant job but one that is vital to the development of safety in air-carrier and non-air carrier flying.

There are two points which should be noted carefully before discussing details of the aircraft-accident situation: (*a*) The Civil Aeronautics Board has jurisdiction only over United States civil flying and, therefore, this paper deals exclusively with accidents involving civil aircraft of United States registry. (*b*) Air carrier accidents and non-air carrier accidents are treated statistically as separate entities.

SCHEDULED AIR-CARRIER ACCIDENTS

All scheduled air carrier accidents are carefully investigated by the Board's Bureau of Safety Investigation and, in the interest of speedy corrective action, the lessons learned are relayed to other government agencies concerned and to the industry.

Scheduled air carrier flying really got started on a practical economic basis with the advent of transport aircraft having passenger seating capacities of 15 to 20 persons. From that time on the curve with respect to both passenger-miles flown and aircraft performance has been steadily upward. The year 1938 is the first for which we have reasonably complete exposure data, particularly miles flown in specific-model aircraft. A few comparisons between that year and 1948 will afford some idea of the magnitude of air carrier growth in the 11-year period (Table 1).

TABLE 1 PASSENGER FATALITIES PER 100 MILLION PASSENGER-MILES[a]

	1938	1948	Per cent of increase or decrease
Airplane-miles	75,282,286	41,4725,998	+ 451
Passenger-miles	613,218,158	81,8972,6000	+ 1235
Fatality rate, per cent	5.2	1.3	— 75

[a] CAB statistics, references 6 and 7, in Bibliography at end of paper.

A comparison of the Douglas DC-3, frequently called the workhorse of World War II, and the Boeing 377, the latest of our transport aircraft, will illustrate performance and design trends (Table 2).

During the year 1948 there were 64 accidents[1] in scheduled air carrier flying. Fortunately, only six of these were fatal. In these six accidents, 103 passengers and 25 crew members were killed. The fatality rate was 1.3 which compares very favorably with 1.6 in 1947, and 1.0 in 1949.

Crash-Injury Protection. Probably the oldest safety problem and certainly the one which has escaped corrective action longest is crash-injury protection.

[1] See definition of "accident" in Appendix.

TABLE 2 COMPARATIVE PHYSICAL DATA OF TWO CLASSES OF AIRCRAFT

	Douglas DC-3[a]	Boeing 377[a]
Maximum seating capacity (includes crew)	32	92
Normal cruising true air speed, mph	180 @ 8000 ft	312 @ 20000 ft
Minimum approach speed, mph	92	136
Minimum landing speed, mph	71	105
Maximum take-off horsepower	2400	14000
Maximum fuel capacity, gal	822	7790
Wing loading, lb-sq ft at max gross	25.5	81.2
Maximum gross, lb at take-off	25200	142500

[a] Figures for each model are taken from published information.

For instance, too frequently fatal and serious injuries are the result of seat belts breaking and seats tearing loose from their anchorage. The present Civil Air Regulations specify a seat belt which will withstand a forward load of 6 G. Many feel that the requirement should be as high as 20 G, and it has been proved that the human body can be subjected to this seat-belt load without injurious effects.

The problem is to design seats and seat carry-through structure which will withstand the 20-G load without adding a prohibitive weight penalty to the aircraft. A solution is important because any increase in the G-factor will reflect directly in lives saved.

An interesting suggestion for crash protection is rearward seating. This definitely would afford greater protection, providing the problem of seat strength and carry-through structure were solved. Whether the public would accept rearward seating is another question.

Fire Hazard. Also, and of equal importance, is the fire hazard which as one might expect increases with the size, performance, and complexity of our aircraft. This increase is understandable when one considers the additional number of engines, their increased horsepower, reversible and automatic propellers, tankage, fuel lines, hydraulic lines, electrical wiring, heaters for cabins, heaters for anti-icing, fire and smoke warning devices, fire extinguishers, and other components.

In our four-engined transports the fuel tanks are made integral with the wings and center section. The different models vary in fuel capacity from 3600 to nearly 8000 gal. Any large storage of fuel represents a fire hazard, but from the crash standpoint it is easy to visualize the additional hazard inherent in integral tanks. Any appreciable tearing of the skin or opening of the seams will release a tremendous volume of fuel and an intense fire may be expected.

Two long-range projects are now under way which are expected to afford valuable data for the design of integral tanks less vulnerable to crash damage. The CAA Technical Development Center at Indianapolis is conducting one of these projects. Here a launching catapult donated by the Navy is being used to hurl fuel tanks into solid barriers and various types of arresting devices. From this it is hoped to determine how best to design

and seal a tank against crash damage. Another is being conducted by the NACA at Cleveland. In this study, war-surplus aircraft are being crashed against barriers under their own power. Among many other things, it is hoped to determine the sources of ignition in crash fires.

Fire Extinguishing. Pending data from these projects, attention is being focused on affording aircraft all possible fire protection. This involves the nature and amount of the fire-extinguishing agent, as well as the method of application. Present U. S. designs lean to centering the fire-extinguishing agent in convenient locations and piping it through a selective valve system to the areas where protection is desired. This method has several disadvantages in the event of a crash. Principally, the crew may be disabled, and the long pipe lines are likely to become inoperative as a result of impact damage.

The British have done a tremendous amount of work in this field and protect their aircraft against crash fires (1)[2] by placing a container of extinguishing agent in each engine nacelle and connecting these with impact switches which trigger automatically at a given deceleration force. For protection in case of fire in flight these containers may be discharged selectively from the cockpit.

The British also are using methyl bromide exclusively for engine fire protection. This is acknowledged to be a much better extinguishing agent (2) for the purpose than CO_2. However, U. S. civil aircraft are still using CO_2 exclusively because it is less toxic than methyl bromide. Recently attention has been focused on another fire-extinguishing agent, "Monochlorobromethane," called C-B for short, which appears to be equally effective as methyl bromide but less toxic. Another feature of C-B is that it requires less operating pressure than CO_2 (400 psi as against 2000 psi), and it may be piped through long lines effectively.

The large quantity of fuel carried in our four-engined transports makes it appear doubtful whether any aircraft fire-fighting arrangement can do much more than delay the spread of a crash fire. This is of the utmost importance, however, since the time element available for evacuating personnel in a major crash fire is a matter of seconds. For this reason it is equally important that passengers be afforded the maximum number and size of emergency exits for speedy cabin evacuation. Our records indicate that the time element is so short in major crash fires even though the accident occurs at an airport that ground fire-fighting equipment is of little assistance unless it has been alerted that a crash is imminent and is ready for instant action. This poses a serious problem since neither fire-fighting equipment alone nor the maximum in emergency exits alone will solve it. A study of some of our major crash fires indicates that a combination of the two is essential if successful evacuation is to be accomplished.

MAJOR SAFETY PROBLEMS

The following are but a few of the safety problems confronting the designers of large aircraft. The answers to many are tied up in long-range research programs. Those cited are considered most important because they are amenable to relatively quick solution, and any reasonable degree of progress will reflect directly in lives saved. These are:

1 The protection of passengers against crash injury by increasing the strength of seat belts, seats, and seat carry-through structure.

2 Methods for delaying the spread of crash fires by affording the aircraft more efficient and automatic fire-fighting equipment.

3 The provision of ample emergency exits of the largest practical size.

PRIVATE FLYING

Non-air carrier or "private flying" consists principally of fixed-based operations such as student training, local passenger flights, charter flights, pleasure flying, crop control, aerial advertising, company transportation, and similar operations. Accidents in these categories of flying occur with such frequency that it would be impractical for CAB accident personnel personally to investigate all of them. However, the Board does make extensive investigations of the more important ones, and all are reported to the Board with sufficient detail for complete analysis (10).

Non-air carrier flying received its first real impetus shortly after World War I when the Government made hundreds of war-surplus airplane engines available to the public at extremely low prices. It grew steadily through 1947, its peak year. Since that time it has experienced a slow decline. A partial explanation for this is the sudden governmental restrictions on eligibility for G.I. flight training. Unquestionably, this curtailed some operations but there are other factors of equal consideration, namely, the tremendous cost of owning and operating an airplane, the lack of utility of the private airplane, and the fear of learning to fly brought about by the excessive number of accidents. Non-air carrier accidents receive relatively little national publicity but the attention they receive locally is deadly to the industry.

During 1948 there were 7850 accidents[1] in non-air carrier flying. Eight hundred and fifty of these were fatal, killing a combined total of 1384 pilots, student pilots, and passengers, and seriously injuring 852 others. In these accidents, 2191 aircraft were destroyed and 5612 were damaged substantially. This is not a healthy condition. By comparison, the scheduled air carriers that same year, in domestic and international operations combined, had but 64 accidents, only six of which were fatal, resulting in death to 128 passengers and crew. The scheduled air carriers flew over 69 million miles per fatal accident, the non-air carriers less than 2 million.

A fairly good perspective of these non-air carrier accidents may be obtained through a breakdown of the types of accidents and their causes. The types of accidents are given in Table 3.

TABLE 3 TYPICAL PRIVATE-FLYING ACCIDENTS[a]

Type of accident	All accidents	Fatal accidents
Collision with objects[b]	1364	137
Stall	1184	416
Nose-up or nose-over	1095	0
Hard landing	1014	5
Ground or water loop	427	0
Overshoot	367	1
Undershoot	216	1
Airframe failure	201	35
Collision of planes on ground	173	2
Miscellaneous (numerous small groupings)[c]	1809	253

[a] CAB statistics (8).
[b] Trees, wires, poles, fence posts, etc.
[c] As a matter of interest, the miscellaneous grouping includes 32 collisions of aircraft in flight, 20 fires in flight, and 13 fires on the ground.

It is apparent from the tabulation that collision with objects, stalls, nose-ups, and hard landings occur with much greater frequency than any of the other types of accidents. From the standpoint of seriousness, however, stalls stand alone because they are the deadliest of all types. Of the 1184 stall accidents, 416 or 35 per cent were fatal to one or more persons on board the aircraft, and of more significance, 49 per cent of all fatal acci-

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

TABLE 4 CAUSES OF PRIVATE-FLYING ACCIDENTS[a]

Cause of accident	All accidents	Fatal accidents
Pilot error	5853	759
Power-plant failure	652	16
Weather	468	9
Airport-terrain	304	0
Landing-gear failure	220	0
Personnel other than pilot	207	21
Airframe failure	59	11
Undetermined	47	32
Equipment—accessories	23	1
Miscellaneous	15	1

[a] CAB statistics (8).

dents in non-air carrier flying in 1948 were caused by stalls. The causes of these accidents are given in Table 4.

Pilot-error accidents completely overshadow all other causes combined. In 1948, a typical year, pilot error was the primary cause of 75 per cent of all accidents, and 90 per cent of the fatal accidents. A recent study (9) of the fatal pilot-error accidents disclosed that 75 per cent fell into three categories as follows:

1 Reckless flying.
2 Failure to maintain flying speed.
3 Continued VFR[2] into instrument weather.

The study also showed that stalls were involved in over one half of all fatal pilot-error accidents and in 60 per cent of those falling into the three foregoing groups.

Reducing Stall Hazard. It must be remembered that there is a limit to the skill that can be demanded of private pilots if private flying is to prosper. Reducing the deadliness of the stall probably would do more to increase the safety of non-air carrier flying than any other single factor.

The practical solution to this problem lies in aircraft design. Just how much the designer can do is indicated by the fact that on the basis of the number of aircraft the Civil Aeronautics Administration lists as having active airworthiness certificates, two highly spin-resistant types of aircraft and one spinproof type in 1948, averaged one fatal stall accident for over 800 aircraft. The over-all average for single-engined aircraft was one fatal stall out of but 186 aircraft. This is significant—one in 800 as against one in less than 200. Here by design alone the deadliness of the stall was reduced 75 per cent (9).

The Civil Aeronautics Board, in recognition of the inherent safety in spinproof and spin-resistant aircraft, adopted a change in Part 20 of the Civil Air Regulations effective August 15, 1949, which eliminated spins from the pilot-certification requirements. One of the primary purposes of this change was to encourage manufacturers to build and operators of schools to use spin-resistant and spinproof aircraft.

The Board is frequently asked if stall-warning indicators are improving the accident picture. Unfortunately, we do not have sufficient exposure data to evaluate the stall-warning indicator from the standpoint of accident prevention. It appears, however, that a reliable stall indicator would do much to help pilots avoid stalls with present-day aircraft. Dr. P. J. Rulon (5), in a recent report, states that experienced pilots do not recognize the actual stall point of light aircraft if the maneuvers are varied. Also, we know that experienced pilots flying for their first time in aircraft equipped with a stall-warning indicator are amazed at the many times they approached a stall while executing maneuvers at air speeds they had considered well above the stall point. Therefore it appears that even in spin-resistant aircraft the stall-warning indicator should rate along with the air-speed indicator as a flight instrument, because it would permit the pilot to learn the stall characteristics of the aircraft he is flying.

Crash Protection. Next to stalls in importance is the problem of crash-injury protection. Although on the average only one to four persons are exposed in non air-carrier accidents, crash protection involves much more than strengthening seat belts, seats, and seat anchorages. In smaller-type aircraft, all of the occupants sit in the cockpit, so to speak, and there is no large amount of structure to absorb crash shock. Here, if crash protection is to be accomplished, the designer must consider such problems as a control wheel that will not break off and permit its shaft to puncture the pilot's chest, an instrument board so located and designed that front-seat occupants will not receive fatal head injuries, a nose section with sufficient strength to keep the engine from being forced back into the pilot's lap, and many others.

The potentialities of crash-injury protection in reducing the annual toll of fatal and serious-injury accidents has been recognized for some time. However, it was not until Hugh DeHaven (3, 4) became interested in the problem that we began to get answers. As Director of the Crash Injury Research Project under the auspices of the Cornell Committee for Air Safety, he has made remarkable progress in developing data essential to practical corrective designing. The problem now is to convince manufacturers of the value of crash-injury protection to their product and to the industry. A few are now making use of Mr. DeHaven's data and experience, and it is believed that the results will prove convincing to all aircraft manufacturers.

Collision. Collision with objects, although not so important as spin resistance and crash protection from the standpoint of injury, occurs with greater frequency than any other type of accident and exceeds stalls in the number of airplanes destroyed and badly damaged. Here, as in the pilot-error category, more care and attention on the part of the pilot would reduce collision accidents materially. Again, however, it must be remembered that the level of performance, particularly for private pilots, is pretty well established and any increase in pilot requirements will reflect directly on the industry through a reduction in the number of prospective pilots. Such a large number of accidents falling into the collision category is sufficient indication that cockpit visibility should be improved, particularly with respect to approach and take-off configurations.

Design Qualities. Emphasis is placed upon those problems which lend themselves to relatively quick solution and for which any reasonable degree of accomplishment will reflect directly in lives saved.

In the design of the aircraft the following qualities must be included:

1 Sufficient spin resistance to insure reasonable control at stall speeds.
2 The maximum in crash-injury protection.
3 The maximum of cockpit visibility, particularly with respect to landing and take-off configurations.

CONCLUSION

Statistics show that non-air carrier flying is experiencing a slow decline. The loss of government assistance by way of sponsored training programs demonstrates that the public has not accepted this kind of flying as rapidly as the industry has expanded. Aside from economic considerations, probably the greatest reason for nonacceptance is fear. A great percentage of

(*Continued on page 558*)

[2] VFR ("visual flight rules") includes flights in which weather below minimum authorized for flying by means of visual contact with the ground was encountered, and the pilot either attempted to continue visual flight or to fly by reference to instruments without proper qualifications or equipment.

More AIR TRAFFIC *With* GREATER SAFETY

By S. P. SAINT

DIRECTOR, AIR NAVIGATION AND TRAFFIC CONTROL DIVISION, AIR TRANSPORT ASSOCIATION, WASHINGTON, D. C.

WE STAND in the middle of the most interesting era in the history of aviation. In the past 8 years we have seen airline transports grow from 12 tons to 70 tons. Cruising speeds have stepped from 175 to 330 mph. Our pressurized cabins carry passengers and crew comfortably at 18,000 to 25,000 ft, above the highest mountains and above most of the ordinary vexations of weather. Nonstop cruising ranges have stretched from 1200 miles to 4000 miles.

This tremendous improvement in the airplane itself, plus the impetus of World War II, plus the general prosperity we are enjoying, have combined to build the volume of airline business to 6 times its prewar level. In 1949 the passenger mileage flown by the scheduled airlines came within 8 percentage points of equaling all first-class rail transportation. Some 3,950,000 airline landings and take-offs were made in 1949.

This almost unprecedented rise of the airline industry has given birth to new problems. The 6-times increased volume of traffic has created new problems in both air navigation and traffic control. We are fast running out of maneuvering space in the sky over our larger cities! The New York area, for instance, is crisscrossed with a maze of unseen radio tracks in the sky. At Chicago, we can land one airplane every 3 min even though the clouds are below the tops of the downtown buildings. But we must learn how to land twice this number.

The goal being set by the planners who are tackling this problem is a tough one. It is this: 40 planes on and 40 planes off per hr at a dual runway airport regardless of the weather. This means an average of one landing or one take-off every 45 sec. This rate is more than double the best that can be done today. This rate will equal the clear-weather capacity of the airport, and thus make possible, for the first time, realistic scheduling.

Stated in another way, the goal of system planning is to move 3600 passengers per hr in and out of an airport in weather thick enough to slow highway traffic. This is the goal that must be met in from 5 to 10 years if aviation is to continue its normal growth. We believe the goal of 80 operations per hr on a single airport under weather ceilings of 100 ft can be achieved within this period. And, what is more important, we believe that the same basic system will handle even larger numbers of planes for the military. The tighter tolerances possible in a disciplined military operation will allow the same system to land more planes in still lower weather conditions.

This system has been called the "common system" of air navigation and traffic control. It is called common because it will serve both civil and military in the common cause of national defense. This is the program being supported by the Congress.

During the 10 years which lie ahead, major attention will be given to electronic development. Development of the common system of air navigation and traffic control—known throughout the air industry as the SC-31 system—had its birth in Special Committee 31 of the Radio Technical Commission for Aeronautics. This committee has been awarded the Collier Trophy for what is now recognized as a trail-blazing step toward a better future for aviation.

Contributed by the Safety Committee and presented at the Spring Meeting, Washington, D. C., April 12-14, 1950, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

PAST ACCOMPLISHMENT IN FLYING SAFETY

In promoting safety, we have worked the wrinkles out of several new high-performance airplanes. We are rapidly converting our postwar fleets to these faster, safer, and more comfortable flying machines. For instance, we have put in service a twin-engined transport that will outclimb and outfly its twin-engined predecessor with one engine inoperative. Fuel reserve, range, and speed have advanced unbelievably.

The pilot enjoys automatic synchronization of propellers and automatic control of temperatures and pressures. He has at his finger tips the controls of an electronic pilot. This instrument is a miracle of co-ordinated perfection that a child could operate. When he flies the airplane manually, the pilot finds control forces unbelievably light. Forty-five tons of DC-6, sliding along at 300 mph, responds in the same smooth and well-behaved manner we expect of a good automobile. When he lands, the pilot gives an extra tug on the throttles, propeller blade angles reverse, and the full power of the engines is available to help bring the airplane to a stop on an icy runway. Ask any pilot how reversible propellers have increased the safety factor.

Navigational facilities are in the process of great advances. The very high-frequency omnidirectional range is replacing the old and static-ridden low-frequency range. Instrument landing systems and ground radar are no longer things we brag about in the press and argue about in committee. We are using these new tools to get the traveler there faster and safer in worse weather. These are some of the things we have done since the war.

PRESENT PLANS TO PROMOTE FLYING SAFETY

Approach-light systems are finally being installed. Approach lights reach out along the approach path to lead a pilot visually out of the clouds onto the runway. For nearly 20 years we have been afraid of blinding the pilot. Since the war, an energetic test program at Arcata, Calif., one of foggiest spots in the United States, has provided some real answers. Hundreds of hours have been flown under zero ceilings with forward visibilities as low as 200 ft. Here it has been found that more light is the answer.

CAA is now installing approach lights with the real horsepower to do the job. Neon-bar systems with a steady-burning total of 15,000 cp are being discarded. In their places, installations that punch into the overcast with more than 25,000,000 steady burning candle power are being provided. Every installation that goes in means an increased safety factor.

Already in limited service is what is known as a "black box" automatic approach. Black box is slang for any new elec-

tronic device carried in an airplane. Automatic approach means automatic hands-off guidance of the airplane down through clouds to a runway. A small black box ties the electronic automatic pilot to the indicator signal of the instrument-landing system. The pilot throws a switch and the airplane, figuratively speaking, slides down a string to the runway by itself.

The pilot's first reaction is to resist the encroaching push-button age. He soon finds, however, that the perfect, automatically flown approach leaves more free time to think, and double-check, and guide the destiny of the ship he commands. He realizes he is paid for his experience and judgment, not to chase needles across dials with wheel and rudder.

As the automatic approach comes into regular service the safety factor inevitably will move up another notch.

In the next few years we will see greatly increased use of ground radar for air-traffic control. There are four surveillance radars installed at commercial terminals in the United States today. By the end of 1951 there will be at least 25 installations.

Another type of radar is going into service. These radars are known today as "precision approach radars." They are more familiarly known as GCA, or "ground controlled approach radars." These radars have a very high resolving power. The operators of these radars watch the progress of airplanes approaching runways through clouds. They warn of unsafe conditions and "talk down" airplanes unequipped with the instrument-landing-beam receiver. Three of our busiest commercial airports are already equipped. These three installations have already averted tragedies. Fifteen new installations of precision approach radar are going in within the next 2 years.

Another type of radar is in the offing. Air-borne radar—a radar carried in the airplane itself—seems destined to fulfill an essential role in our faster airplanes. A radar can "see" thunderstorms and bad icing conditions, as well as mountainous terrain, even when flying in the clouds.

BASIC PROBLEMS OF FUTURE DEVELOPMENT

The most urgent problem we face today is solution of our communications bottleneck. We need an automatic, visual indicating, private-line type of instantaneous communications system.

That sounds complicated. It means that we need to give the pilot a visual signal indicator in the cockpit similar to the cab signals now in use on the railroads. This indicator must be operated automatically. It must permit simultaneous transmission of separate and distinct messages to many airplanes on a private-line basis.

We can no longer afford the delay of waiting in turn for an overloaded party-line circuit. Overloaded radio voice circuits are already costing untold thousands of hours of delay and confusion. It must follow, of course, that safety factor is adversely affected by jammed-up radio circuits.

The use of more frequencies is not the answer. There are 12 radio transmitting frequencies used in the La Guardia tower today. It will be realized that this number of circuits is already creating an almost impossible co-ordination problem.

We need a fast automatic communications system that puts simple visual signals in the cockpit. These signals will lead the pilot step by step. He will not have to memorize a long and difficult clearance while running up his engines getting ready for take-off. Several techniques are known. There is more than one such system already operating on the laboratory bench.

Another urgent need of the future is "picture navigation." We need to show the pilot a complex navigational problem in simple picture form. In the New York area, for example, there are 366 miles of airways including 38 radio fixes and intersections within a 30-mile radius of La Guardia Field. The number of possible routings, including altitudes, in and out of La Guardia Field alone is almost impossible to count.

A pilot may be required to fly four or five different courses in the first 10 min when departing from a busy terminal. A radio-range signal, a gyrostabilized compass, and an automatic direction finder must all be mentally integrated by the pilot into a picture of where he is, which way he is headed, and which way the sometimes unknown wind is drifting his plane.

If, on the other hand, this complex information is combined in a simple picture, the pilot's work load is reduced to a fraction of what it was before. He is shown the route to follow, where he is, and the direction in which he is heading. He gets it in a single glance. Picture navigation will cut down the work load on the pilot. It will cut down the probability of mistakes. On both counts the safety factor will be increased.

Perhaps equal in importance with the need for pictorial navigation is the need for an automatic traffic-control system. Special Committee-31 of the Radio Technical Commission for Aeronautics has long recognized the need for such a system. But even before SC-31 wrote this requirement several manufacturers had already gone to work on the problem.

Already a completely automatic block-signal system for air-traffic control has been developed and flight-tested. This system directs the pilot by simple "cab" signals in the cockpit. It operates in much the same way that a railroad block signal system operates.

Two other manufacturers have combined television and radar techniques to give the pilot a television-type picture on the instrument panel in the cockpit. This picture is designed to show the pilot his position and desired course and give him traffic-control information as well. At least seven manufacturers have made specific proposals covering various methods of automatic traffic control. This all adds up to a confusion of operational requirements and technical possibilities.

In Washington a three-way coalition of responsible agencies is attempting to solve this particular problem. The Research and Development Board and the Navigation and Traffic Control Panel of the Air Coordinating Committee are co-ordinating the broad operational requirements outlined by Special Committee-31 into detailed military and common-system operational requirements. The Air Navigation Development Board, third side of the triangle, has been established to convert operational requirements into tangible equipment. This board has the task of leading the varied and complex interests down a common avenue toward the common system of air navigation and traffic control.

RECOMMENDATIONS

It should always be kept clearly in mind that an airplane is flown by a normal, ordinary, flesh-and-blood human being. The pilot's job must be simplified. Any further increase in the mental work load on the pilot must be ruled out with iron-clad determination. Safety factor in flight is often measured by the margin between what a human pilot can do and what he is required to do. There is a dangerous tendency to have the pilot learn a new procedure to cover a weakness in equipment or system design.

This point can be illustrated with the simple matter of runway markings. Most airline pilots are qualified to land and take off from a large number of airports. Some of the most critical, the most instantaneous decisions a pilot is ever called upon to make have to do with landing and taking off. The most critical factor in these decisions is: How much runway is available? Or how much runway do I still have in front of me? Wind, rain, ice, flying speed, and weight of the airplane must all be related to available runway length.

The toughest decisions of all are made when an unknown length of runway is behind and an unknown length of runway is still in front. The single most critical decision of a pilot's career may be based upon his instantaneous estimate of how much concrete is in front of him. He makes this estimate on the basis of a few distant green lights swimming in the rain on the windshield. He makes this estimate while moving at perhaps 120 mph.

It seems clear that a concentrated effort to simplify the pilot's job would result in better airport markings. Lighted distance markers, a sign with numbers on it large enough to read, placed every 1000 ft along the runway would certainly increase safety factor out of all proportion to the cost involved.

Greater effort should be made to get at the real underlying cause in our accident investigations. Too often we pin the blame on the first human we come to in working back along the tragic chain of events. This person is usually the pilot. Many times we fail to uncover more significant facts, perhaps a basic weakness in the design of equipment or facilities.

The author is convinced that there are numerous cases on record where the underlying cause of an accident has been overlooked because it was a familiar and accepted part of our daily operation. Too seldom do we ask: What stacked the cards in favor of this accident? Here are two specific examples:

1 There is much evidence in the record of past accidents that points to the need for a better altimeter. The possibility of misreading the present type of altimeter is an established fact. The number of accidents in which the altimeter is suspect is out of all proportion to the present small effort to build a better altimeter. To avoid the confusion possible in reading clocklike indications, it should be redesigned to read like an odometer—that is, like the mileage reading on a speedometer. It should be inherently self-checking. It also should have a limit-warning switch that could be set by the pilot to call his attention if the flight path descends below a safe altitude for the area involved.

2 There is ample evidence behind the surface causes of certain accidents to indicate the need for better protection against stalls. As is well known, a stall is that point at which the smooth air flow over the wing is broken. It is that point at which lift drops sharply and drag increases. The airplane starts to fall out of control. The stall point is normally related to air speed. It is necessary to realize that final maneuvering for landing must be done at speeds approaching the stall speed if the airplane is to be landed on a runway and brought to a stop. But airplanes stall at different speeds depending on load, angle of bank, and other factors.

It is believed that many past accidents point to the need for an angle-of-attack indicator as a stall-warning device. Furthermore, this device should include an attention-calling signal as the dangerous angle of attack is approached. Stall-warning devices have been built and put in limited service. They are simple and relatively foolproof. The potential increase in safety factor inherent in a stall-warning indicator is not yet fully realized.

CONCLUSIONS

Tremendous strides have been made in air navigation in the past few years, but what has been outlined briefly in this paper should indicate the necessity for still more far-reaching developments in the interest of safety. In 1949, it should be recalled, the scheduled airlines made nearly 4,000,000 landings and take-offs. The increasing pressure on air traffic demands continued application of electronic and mechanical devices to remove, in so far as humanly possible, the hazards which still remain. There is much fertile ground yet to be cultivated!

Accident Statistics Can Contribute to Safer Flying

(Continued from page 555)

potential pilots who have the urge to learn to fly are discouraged by family and friends. This is understandable when one considers the annual toll in lives and aircraft. To overcome this the aircraft must be designed to require less skill to fly safely and it must afford the occupants the maximum protection from crash injury. Fortunately, the know-how for accomplishing this is not tied up in long-range research.

Our U. S. scheduled air carrier flying has made remarkable progress since 1938. The increase in mileage covered and improvement in aircraft performance is truly spectacular, and, while improvement in the fatality rate has been slower, this too is very good when considered in terms of the tremendous increase in airplane and passenger-miles.

Probably the greatest single threat to this safety record is the fire hazard inherent in the larger transport aircraft. Where large quantities of fuel are carried, fire following crash spreads with great rapidity. The passengers' chance of survival can be improved materially by designing into the aircraft the maximum protection from crash injury, providing the aircraft with a more efficient and automatic crash-fire protection system, and increasing the size and possibly the number of emergency exits.

In the constant effort of government and industry to improve the safety of flying, emphasis naturally focuses on the weakest links. To evaluate the true safety picture, the bad must be weighed with good.

It is gratifying to note that in 1949 our scheduled air carriers established a safety record of one fatality per 100 million passenger-miles. Our international carriers have flown over 4 billion passenger-miles and carried over 2 million passengers since their last fatal accident. No other country in the world with operations remotely comparable with ours can approach this safety record.

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Appendix

CAB DEFINITION OF AN AIRCRAFT ACCIDENT

"For statistical purposes an aircraft accident is considered any occurrence 'incident to flight' which results in 'fatal' or 'serious injury' to one or more persons and/or 'destruction' or 'substantial' damage to the aircraft. A collision of two or more aircraft is considered one accident."

THERMAL CRACKS *in* TURBINE *and* GENERATOR ROTOR FORGINGS

By A. W. RANKIN,[1] C. J. BOYLE,[2] C. D. MORIARTY,[2] AND B. R. SEGUIN[2]

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

GENERAL

THE company with which the authors are associated recently experienced a short period in which considerable trouble was encountered in insuring that the forgings used for large turbine and generator rotors were free from thermal cracks. This period coincided with the introduction by this company of ultrasonic inspection of its large forgings, and since the thermal cracks were frequently so situated within the forging mass as to be invisible to any of the usual routine inspection methods except the ultrasonic methods which can search the interior, it can be appreciated that the interpretation of the ultrasonic results was difficult. Since ultrasonic testing cannot by itself differentiate between a thermal crack and a relatively harmless nonmetallic inclusion, it is necessary that supplementary investigations be made for interpretation of the ultrasonic indications. Accordingly, it was believed that a record of this company's investigations during this period would be of benefit to all those interested in large rotor forgings, and the purpose of this paper is to present the major results of these investigations.

It is generally recognized that hazards are always present in the operation of high-speed equipment, particularly in the large complex equipment needed for power generation, but this serves only to emphasize the necessity of avoiding the introduction of any additional hazards wherever possible. Accordingly, this company immediately rejects any rotors in which thermal cracks are found, regardless of the size or number of the cracks.

This paper presents (1) a general review of the results of ultrasonic testing during the period in question, with the results on the first three questioned rotors discussed in detail; (2) a discussion of the practical details of ultrasonic testing of large rotor forgings with special emphasis on the need for careful interpretation of the results of such an investigation; (3) the metallurgical investigations on particular rotors, together with a tabulation of some general identifying characteristics of thermal cracks and nonmetallic inclusions; and (4) a description of the spin tests which were made to determine the reduction in the bursting speed of a rotor resulting from thermal cracks of the size and distribution found in this investigation.

RESULTS OF ULTRASONIC TESTING

Prior to the introduction of ultrasonic testing, the inspection routine for large turbine and generator forgings was as follows, this routine being in addition to the inspection routine of the forging manufacturer:

1 Visual inspection by boroscope of forging bores.
2 Magnetic-particle test of fillets at major step downs.
3 Magnetic-particle test of fillets at wheel step downs after machining wheels.
4 Magnetic-particle test of journal areas.
5 Magnetic-particle test of several rotor slots in generator fields.

The foregoing methods, which in general are representative of the best routine inspection practice available at the time, are adequate for locating any discontinuities which break through to the surface tested, but, obviously, cannot detect any subsurface discontinuities (unless so close to the surface as to affect the magnetic results). Late in 1947, however, ultrasonic testing was introduced, and such tests then became part of the normal inspection routine.

Shortly after the introduction of ultrasonic testing, a few sonic discontinuities were located on a low-pressure rotor, hereinafter referred to as rotor C. These discontinuities, however, were so few in number and so minor in severity that the rotor was released for manufacture and shipment. In Fig. 1 the upper oscillogram shows the sonic reflection from an unquestioned section of this rotor with the bore reflection showing at 11 in.; the lower oscillogram shows the sonic reflection from the questioned area. A sonic discontinuity can be located ahead of the bore reflection, at the 10-inch radius, but is so minor as to be barely visible.

After the release of rotor C, the next rotor to be questioned because of ultrasonic results was a 65,000-kw generator rotor, hereinafter referred to as rotor D, on which ultrasonic discontinuities were found throughout the entire rotor. The oscillogram in Fig. 2(*a*), shows the bore reflection at $10^1/_4$ in., and a major sonic discontinuity at 5 in. The sonic discontinuity is so large as partially to shield the bore, and cause the bore reflection to be less than the reflection from the discontinuity at the 5-in. radius.

Action was taken immediately to determine the cause of these ultrasonic results. Two rods were core-drilled as directed by the sonic tests. In Fig. 2(*b*) is shown one of the core-drilled rods after magnetizing and applying magnetic powder. The magnetic discontinuity is clearly visible. Fig. 2(*c*) shows the same discontinuity at a magnification of 100×, and inspection under the microscope proved this discontinuity to be a crack. Similar results were obtained on the second core-drilled rod.

The entire bore was then given a magnetic-particle test with white light and black magnetite, and also with ultraviolet light and a fluorescent powder. Magnetic discontinuities were located immediately. This forging was rejected, but, after arrangements with the forging manufacturer, was parted through the body so as to expose a transverse view. The exposed plane was then magnetic-particle-tested. Fig. 2(*d*) is a view of the central 11-in-diam region within which all the cracks were located, and on which they are plainly indicated.

It was decided that high-speed spin tests should be conducted on this forging in order to determine the effective strength of a rotor with such thermal cracks. These spin tests are reported in a later section of the paper.

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[1] Steam Turbine and Generator Engineering Divisions. Member ASME.

[2] Schenectady Works Laboratory.

Contributed by the Power Division and presented at the Spring Meeting, Washington, D. C., April 12–14, 1950, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Almost immediately after the sonic tests on rotor D, major sonic discontinuities were found in a 75,000-kw generator rotor, hereinafter referred to as rotor L. An immediate magnetic-particle test of the bore disclosed major magnetic discontinuities, and the forging was rejected. In Fig. 3(*a*) is shown an oscillogram of the sonic reflections. The bore reflection is shown at 15 in. with discontinuities shown at $6^{1}/_{4}$ in., 10 in., and 12 in. The body portion of the rotor was machined flat on two sides in order to investigate the quality of the forging material at various radial locations. The forging was then parted axially so as to expose a longitudinal view through the bore. Fig. 3(*b*) shows the resultant plane, together with inserts at a magnification of 1×. The discontinuities were located sonically and verified magnetically on this plane. A transverse plane was later exposed and tested by the magnetic-particle method; the magnetic discontinuities so located are shown in Fig. 3(*c*).

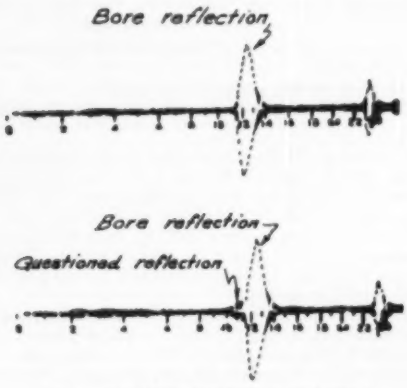

FIG. 1 ULTRASONIC REFLECTIONS OF ROTOR C
(*a*, Upper oscillogram shows reflection from an unquestioned portion of rotor; bore reflection at 11 in. *b*, Lower oscillogram shows reflection from questioned area; note small sonic reflection, at 10 in., ahead of bore reflection.)

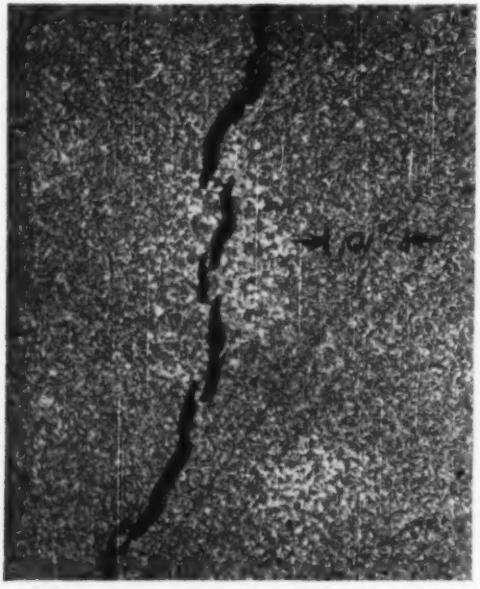

FIG. 2(*c*) DISCONTINUITY IN FIG. 2(*b*) AT A MAGNIFICATION OF 100×

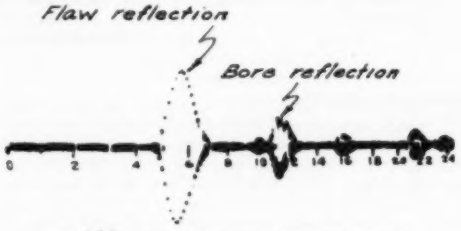

FIG. 2(*a*) ULTRASONIC REFLECTIONS OF ROTOR D
(Bore reflection at $10^{1}/_{2}$ in. with flaw reflection at 5 in.)

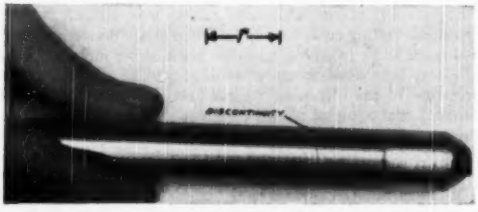

FIG. 2(*b*) CORE-DRILLED ROD FROM ROTOR D SHOWING MAGNETIC DISCONTINUITY

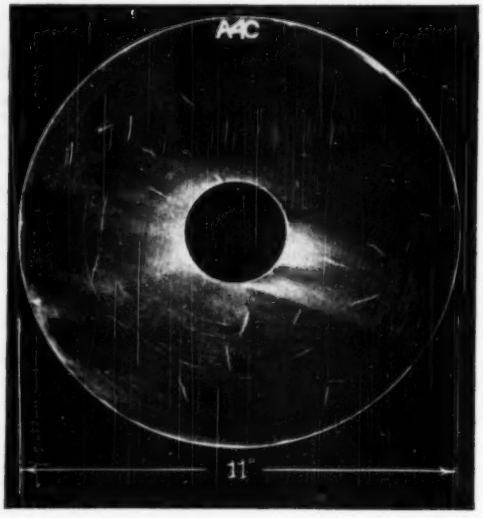

FIG. 2(*d*) CENTRAL 11-IN-DIAM REGION OF TRANSVERSE PLANE OF ROTOR D WITH MAGNETIC DISCONTINUITIES SHOWN BY ULTRAVIOLET LIGHT AND FLUORESCENT POWDER
(Outside diameter $35^{3}/_{4}$ in.)

Further sonic testing of turbine and generator rotors under construction at this time resulted in the questioning of a number of additional rotors. The investigation on these proceeded in the manner described for rotors C, D, and L. It is unnecessary to discuss these at any length at this point as further detailed investigations are reported later in the paper. It is sufficient to state that a number of the ultrasonic discontinuities were found to be thermal cracks. The cause of the cracking was quickly located in a recent modification of the manufacturing

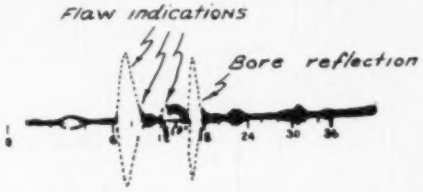

FIG. 3(*a*) ULTRASONIC REFLECTIONS OF ROTOR L
(Bore reflection at 15 in. with flaw reflections at 6¼ in., 10 in., and 12 in.)

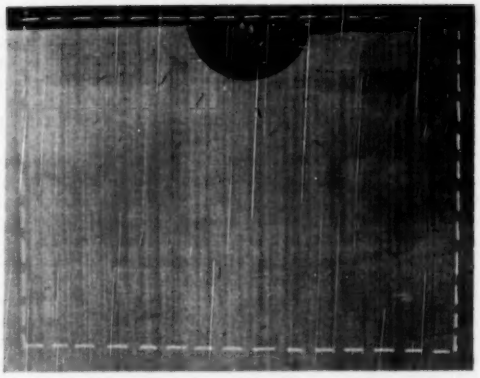

FIG. 3(*c*) TRANSVERSE PLANE OF ROTOR L SHOWING MAGNETIC DISCONTINUITIES
(Bore is 6½ in. diam.)

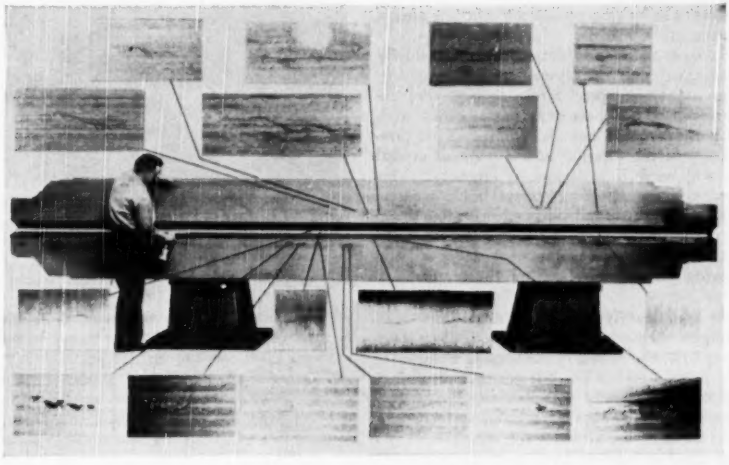

FIG. 3(*b*) LONGITUDINAL PLANE OF ROTOR L WITH INSERTS SHOWING MAGNETIC DISCONTINUITIES AND THEIR LOCATIONS

process at the steel mill, which was corrected immediately. It was possible to sonic-test every turbine and generator forging manufactured with the modified practice since none had been shipped to the turbine purchaser.

ULTRASONIC TESTING OF TURBINE AND GENERATOR FORGINGS

During World War II the authors' company utilized ultrasonic flaw-detection equipment[8] to examine gas-turbine rotors. This application to war materials provided a foundation for the postwar application to large turbine and generator forgings. Fig. 4 shows the present method of ultrasonic inspection of a large generator forging.

Principle. The ultrasonic flaw detector operates on the radar method of using a cathode-ray oscilloscope to visualize the elapsed time between the transmitted sound pulse and the re-

[8] Throughout this discussion of ultrasonic inspection, the term "flaw" is used as synonymous to the more descriptive but somewhat recondite term "sonic discontinuity."

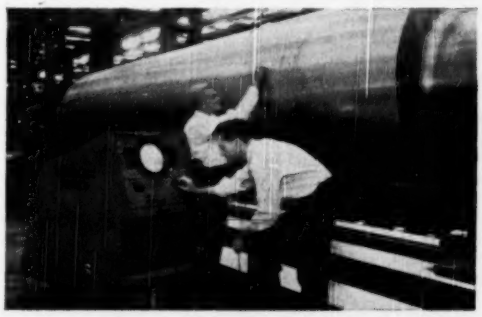

FIG. 4 APPLICATION OF ULTRASONIC TESTING TO LARGE GENERATOR-ROTOR FORGING

flected echo. A sound pulse of 5-microsec duration is sent into the metal, followed by a waiting period of 16,667 microsec for the echo to return to the sending source, this sequence being repeated 60 times per sec. Although this waiting period is long enough for sound to travel to the end of a 172-ft metal bar and back again, the maximum practical distance which can be searched by an ultrasonic beam is of the order of 25 ft.

Piezoelectric crystals are used to generate the high frequencies used in the ultrasonic beam, these frequencies being upward of 1,000,000 cycles per sec. It is only incidental that these frequencies are beyond the range of audibility; their true advantage is the ability to beam them in a given direction.

Application Details. Large rotor forgings are best examined ultrasonically while in steady rotation at about 2 or 3 rpm. With the crystals in contact with forging end faces or periphery through a thin oil film, the rotation of the object around its axis permits an examination of the entire forging in a short time. For example, the ultrasonic test on a 75-ton forging takes approximately 2 hr. During that time every cubic inch of the forging will have been inspected by a spiral thread movement of the scanning crystals from journal to journal, the inhomogeneous areas will have been marked, and any eccentricity of bore will have been revealed. This test is usually performed during the first step in the forging production schedule after a normal f5 finish lathe cut[4] is made.

An important factor in the case of ultrasonic tests on slowly rotating rotor forgings is that the crystal face and rotor surface must maintain steady and precise relationship. For example, when testing on the periphery of a rotating object with hand-supported rigidly mounted crystals, unsteady hand pressure creates variation in the location of the point of crystal contact, and this will result in a fluctuating intensity. This difficulty was overcome by constructing a crystal holder wherein the crystals were free to angulate and independently align themselves tangent to the rotor periphery at the focal center of the crystal, and to retain that surface alignment under a constant light spring pressure exercised on the center point of the crystal.

It can be appreciated readily that when ultrasonic-testing with sliding mechanical contacts as described in the preceding paragraph, the surface of the forging must be fairly smooth. A good surface finish is not necessary for ultrasonic examination if only spot-checking is desired on a stationary object. In the latter case, surface roughness merely results in the necessity for the operator to increase the signal strength of his ultrasonic equipment and thereby compensate for loss of crystal contact area. As an example, the signal strength with 1 megacycle sound drops 25 per cent in going from a finish f1 to f6, and 75 per cent from f1 to f8.

Interpretation. The large size of turbine and generator rotor forgings is an advantage in ultrasonic inspection since reverberations and extraneous echoes are not troublesome. This technical advantage is more than offset, however, by the difficulty of determining if an indication is a crack or a relatively harmless nonmetallic inclusion. It would be economically unsound to predicate rejection of costly material on a testing method which indicates the presence of flaws but does not evaluate their harmfulness. This latter consideration required that a rigid systematic ultrasonic examination of every forging be inaugurated, and that correlation by destructive means be obtained wherever necessary.

In determining the probable degree of harmfulness of a flaw indicated by ultrasonic examination, the common denominator is the intensity of indication from the bore in a flaw-free area. The intensity of indication coming from a flaw is then referred to as the per cent ratio of the flaw reflection to the bore reflection. Fig. 5 shows the distribution of an ultrasonic beam in a forging cross section, while Fig. 6 shows oscillograms revealing flaw indications of 15 per cent and 250 per cent. For a given set of circumstances applicable to this particular investigation, an empirical relation between this intensity ratio

[4] See Appendix for General Electric Company versus ASA finish symbols.

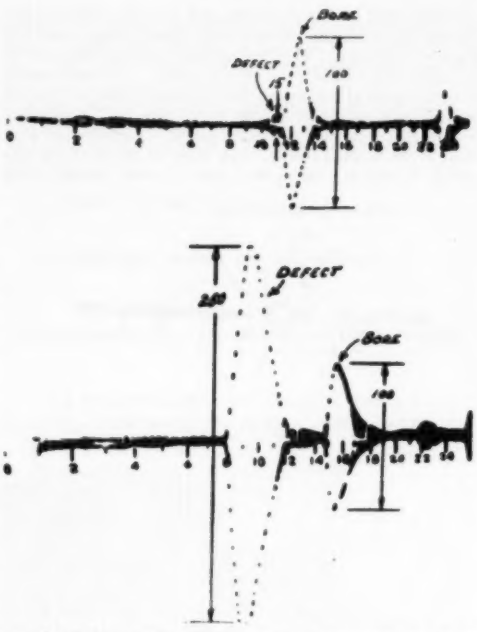

FIG. 6 OSCILLOGRAMS ILLUSTRATING EVALUATION OF FLAW REFLECTION IN PER CENT OF BORE REFLECTION
(Flaw reflection of 15 per cent in upper figure; lower figure shows flaw reflection of 250 per cent.)

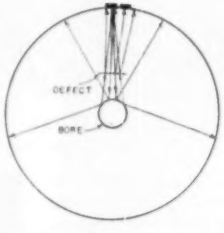

FIG. 5 DISTRIBUTION OF ULTRASONIC BEAM IN FORGING CROSS SECTION

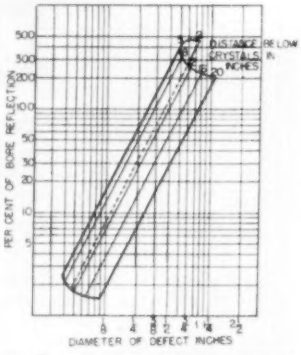

FIG. 7 EMPIRICAL RELATION BETWEEN FLAW REFLECTION (IN PER CENT OF BORE REFLECTION) AND MINIMUM SIZE OF FLAW

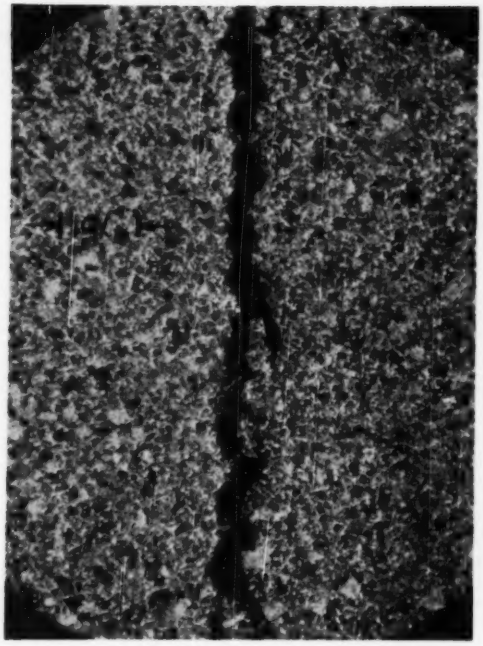

FIG. 8(*a*) PHOTOMICROGRAPH OF THERMAL CRACK WHICH HAD CAUSED A SONIC REFLECTION; 100×

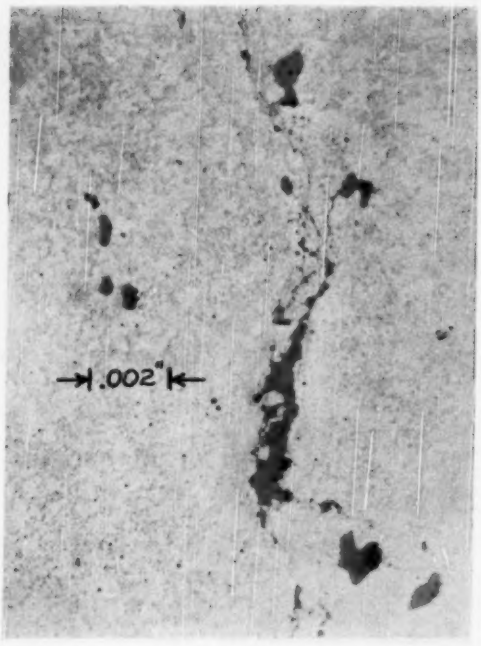

FIG. 8(*b*) PHOTOMICROGRAPH OF NONMETALLIC INCLUSIONS, CONNECTED BY MEMBRANES OF SIMILAR INCLUSIONS, WHICH HAD CAUSED A SONIC REFLECTION COMPARABLE TO THAT CAUSED BY THERMAL CRACK OF FIG. 8(*a*); 500×

and the minimum size of flaw it represents may be obtained as shown in Fig. 7.

Regardless, however, of the flaw-bore intensity ratio, or the empirically determined size of flaw, the nature of the source of echo is the primary consideration. The practice of the authors' company in ultrasonic testing is to assume that a detected flaw is harmful (a crack) unless it can be determined otherwise to be harmless. Knowledge of forging practice and where various types of flaws are likely to occur influences interpretation to a considerable degree.

There is no definite difference between an ultrasonic indication coming from a crack and one coming from a nonmetallic inclusion. An oscillogram will only show a particular flaw location and its intensity of reflection as a still picture that is meaningless in itself in deducing the nature of the flaw. The distribution and reflection intensity revealed on the oscilloscope, however, when combined with the metallurgical history of the forging, guides future investigation and disposition.

Quite often the internal distribution pattern of flaws, as shown on the oscilloscope, indicates the probability of the flaws breaking through to the outer surface or to the inner bore surface where they may be identified by a subsequent magnetic-particle test. When this is not the case, a test specimen, whose location has been established by ultrasonic means, is trepanned for metallurgical examination.

METALLURGICAL INVESTIGATIONS

Continued sonic-testing of large forgings and subsequent metallurgical investigation showed that not all sonic indications were caused by thermal cracks. Generally, as noted heretofore, distribution and intensity of sonic indications are an excellent guide for subsequent metallurgical investigation.

Formerly it was believed in some quarters that thermal cracks in a large forging would be located generally at approximately half-radius of the main body. In several of the forgings investigated, the thermal cracks were located in the bore region only, extending radially from the bore for distances ranging from 0 to 11 in. This added to the difficulties of investigation because several of the forgings being investigated were forged from extremely large ingots, some being 108 in. octagonal, and, since the diameters of these forgings approximated 60 in., it would be expected normally that some segregation might be located near the bore.

Sonic and magnetic tests have been described in the foregoing for rotors C, D, and L. The following will describe tests on other forgings that were subject to this investigation.

A 150,000-lb generator forging (60 in. diam) had been partially slotted before the sonic test was made. Sonic indications were obtained 0–17 in. from the bore surface with a magnitude up to 300 per cent of the bore reflection. Two trepanned samples were then removed from locations according to sonic information. The samples were machined smooth and magnetic-particle tested. A major magnetic indication was obtained in sample No. 1, and scattered magnetic indications were found in sample No. 2. After sectioning these indications and examining them under the microscope, it was found that the No. 1 sample contained a thermal crack and that the magnetic indications in the No. 2 sample were caused by nonmetallic inclusions. Fig. 8(*a*) is a photomicrograph at 100× of the crack in sample No. 1. Fig. 8(*b*) is a photomicrograph at 500×.

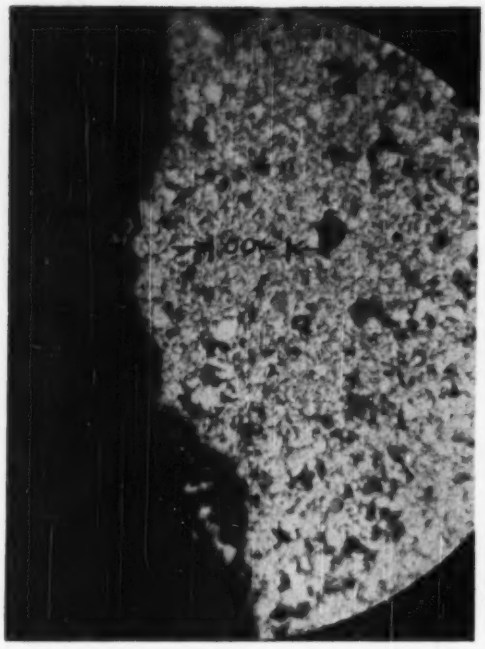

FIG. 9(*a*) PHOTOMICROGRAPH SHOWING LACK OF ELONGATION OF GRAINS ADJACENT TO THERMAL CRACK; 250×

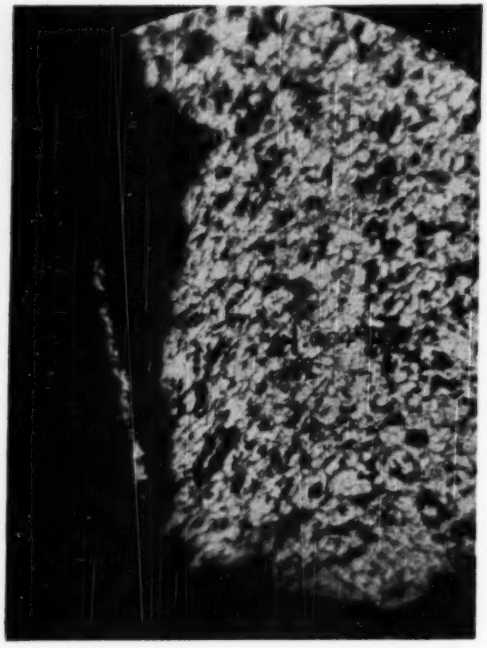

FIG. 9(*b*) PHOTOMICROGRAPH SHOWING ELONGATION OF GRAINS ADJACENT TO BREAK IN TENSILE TEST; 250×

showing the slate-gray nonmetallic inclusions, connected by membranes of nonmetallic inclusions, that were found in sample No. 2. Higher magnification was required for positive identification of the constituents in the membranes. It is believed that there was originally a group of nonmetallic inclusions located near each other in the ingot and that subsequent forging had spread these inclusions about with some of them being squeezed or elongated in the shape of the membranes. A transverse view of the section shown in Fig. 8(*b*), showed a similar pattern, thereby indicating that these membranes formed a plane which would produce the same reaction to sonics as did a thermal crack.

Ultrasonics indicated dimensionally that magnetic-particle indications should be found in the bottom of some of the slots in this forging. Two slots were polished and magnetic-particle-tested, four cracks being found in the bottom of one slot. Because cracks had been found in the trepanned sample and at the bottom of the slots, no attempt was made to magnetic-particle-test the bore of this forging, which was rejected on the basis of the magnetic confirmation of the ultrasonic indications.

Another method for investigating sonic indications was used on a 117,000-lb forging. A sample was trepanned from the forging according to sonic information. This sample was machined smooth and magnetic-particle-tested. A major magnetic indication was obtained on the specimen. The specimen was then machined to a standard 0.505-in. tensile specimen, and the magnetic test was repeated with the same results. The test piece was then stress-relieved for 1 hr at 600 F and pulled with the results shown in Table 1.

TABLE 1 RESULTS OF TENSILE TESTS

Specimen	Tensile strength, psi	Prop. limit, psi	Elong., per cent	Reduction, per cent
Required by specification	80,000	43,000	16.0	28.0
Reported by vendor	92,700	60,000	19.0	45.3
Trepanned sample	45,200	...	...	...

Examination of the fractured surface of the tensile specimen machined from the trepanned sample showed that approximately one half of the surface of the fracture was discolored. Since the test piece had been stress-relieved at 600 F, this discoloration indicated that the test piece was cracked and that the heat from the stress-relieving operation had penetrated the crack and caused the discoloration. This crack would account for the low tensile strength as reported in Table 1, since only one half of the expected cross-sectional area was present. Figs. 9(*a*) and 9(*b*) are photomicrographs at 250× of the two sections at the fracture of the trepanned sample. Note the lack of elongation of the grains at the fracture in Fig. 9(*a*), and the pronounced elongation of the grains in Fig. 9(*b*). Since visual examination of the fracture had shown that one half of the test piece had been cracked, it would be expected that the grains at the cracked area would not be elongated, while those in the solid area would be.

By correlating the experience gained in many years of study of the bores of large rotor forgings, it is possible to tabulate some general identifying characteristics of thermal cracks and nonmetallic inclusions as follows:

Thermal Cracks:

1 Narrow in width (0.005 in. or less) and generally ranging in length from approximately $\frac{1}{2}$ to 2 in.

2 Always have pronounced wiggle.
3 Always present in considerable number.
4 Direction of cracks is at all angles with respect to axis of bore.
5 Roughly circular in shape and appear at machined surfaces as chord of circle.
(*a*) Have depth and, therefore, still present after enlarging bore but as another chord of some circle.
6 Practically impossible to find in bore without magnetic-particle test.
7 Produce considerable bleeding after etching.

Nonmetallic Inclusions:

1 May be same size as thermal cracks, but are generally wider in width and can be very much greater in length.
2 Usually are straight but may wiggle.
3 Majority are axial in direction.
4 Large inclusions having depth can be identified with boroscope, and may be found without magnetic-particle test.
5 Generally small inclusions, appearing like cracks, have little depth and are removed by a slight opening up of the bore.
(*a*) While nonmetallic inclusions can be in the form of a plane, as noted previously, little evidence of this condition has been found in the bore in our experience.
6 Have little or no bleeding after etching.

By employing the identifying characteristics just tabulated, a third method of investigating sonic indications is available, and was used when the sonic indications were located in an area extending from the surface of the bore to several inches away from the bore, and it was not considered practical, because of high stresses, to trepan samples. This method consisted of searching the bore with a boroscope and plotting the sizes and exact locations of all indications observed. The bore was then magnetic-particle-tested and the sizes and locations of the magnetic indications were plotted. The diameter of the bore was then increased in small steps, and the foregoing two tests were repeated. The indications were plotted and compared with those obtained before opening the bore. By comparing the plots of the indications in the bore at various diameters and applying the characteristics of thermal cracks and nonmetallic inclusions, it is usually possible to identify and interpret the sonic results.

SPIN TESTS

In order to evaluate the degree by which thermal cracks in a rotor would lower the factor of safety which protects against bursting, spin tests were conducted on the rotor material of the D rotor. As detailed earlier in the paper, severe sonic discontinuities were located in this D rotor. Investigation of two of these discontinuities by trepanning samples proved them to be thermal cracks, and the rotor was removed from the production schedule and parted both longitudinally and radially. The remaining sonic discontinuities then proved to be thermal cracks similar to that shown in Fig. 2(*c*).

Two types of spin tests were conducted as follows:

1 *High-speed tests* in which the speed was increased until bursting occurred.
(*a*) These Type 1 tests were planned to obtain a burst on the first run, but, owing to difficulties in holding a disk with a center hole with the entire disk in the plastic range, as many as 3 runs were required to obtain a burst.
2 *Overspeed tests* at 120 per cent of normal speed, repeated 100 or 200 times.
(*a*) These Type 2 tests were planned to simulate the starting and stopping of a turbine rotor with each run carried to 120 per cent to see if there was any tendency for the thermal cracks to grow in magnitude. At the end of 100 or 200 runs, the disks were then accelerated to the speed at which bursting occurred.

Two sizes of disks as follows were tested in each of the foregoing type of tests:

1 Disks of full rotor diameter (35$^3/_4$ in.) with a bore hole of 2$^1/_2$ in. diam, taken from that portion of the rotor body containing the thermal cracks. These full-size disks were slotted to simulate the slots in a generator rotor. Rated speed on these disks was 3600 rpm.
2 Model disks of 11 in. diam, with a bore hole of 2$^1/_2$ in. diam. These disks were not slotted as in a generator rotor, but at 13,300 rpm the average bursting stress was the same as the average bursting stress at 3600 rpm in the full-size slotted disks. Rated speed for these 11-in. model disks is accordingly 13,300 rpm.
(*a*) Four 11-in. disks were cut from the central portion of the shaft, this being the region containing the thermal cracks. Tests on these disks should indicate the bursting speed of a rotor with thermal cracks through its entire volume from the bore out to the outer diameter.
(*b*) Four 11-in-diam disks were cut from the outer portions of the shaft, this being the region in which no thermal cracks were present. Tests on these disks should indicate the bursting speed of a sound rotor with no thermal cracks whatsoever.

All disks were straight-sided with the dimensions as summarized in Table 2.

TABLE 2 DISK DIMENSIONS, IN.

(*a*) Full-size disks	
Outer diameter	35.75
Bore diameter	2.50
Thickness	2.00
(*b*) Model disks:	
Outer diameter	11.00
Bore diameter	2.50
Thickness	0.50

The method of evaluating the results of the spin tests is based upon the results obtained in previous studies which showed that the speed at which bursting of a straight-sided disk occurred was that speed at which the average bursting stress equaled the ultimate strength of the material.[6] This is not a precise relationship as for different materials the bursting speed may be either slightly higher or slightly lower than the predicted values, but this relation is quite adequate for engineering purposes. Using this method, the results of the spin tests to bursting can be summarized as in Table 3.

TABLE 3 BURSTING SPEEDS

(A)	Model disk, 11 in. OD; sound material containing no thermal cracks; 2 disks tested	
	1 Bursting speed in per cent of predicted speed	= 107
	2 Bursting speed in per cent of rated speed	= 255
(B)	Full-size disk, 35$^3/_4$ in. OD, disk with central portion containing thermal cracks; 3 disks tested	
	1 Bursting speed in per cent of predicted speed	= 90
	2 Bursting speed in per cent of rated speed	= 213
	3 Bursting speed in per cent of A2 result	= 83
(C)	Model disk, 11 in. OD, cracked material from central portion of shaft; 3 disks tested	
	1 Bursting speed in per cent of predicted speed	= 83
	2 Bursting speed in per cent of rated speed	= 197
	3 Bursting speed in per cent of A2 result	= 77

The test results on the full-size disks (B, Table 3) indicate that the bursting speed is only 83 per cent of that of a sound disk, but that there is still a factor of more than 2 between rated speed and the bursting speed. Hence the D rotor removed from the production schedule because of the presence of thermal cracks still had a considerable factor of safety protecting it against actual bursting.

Fig. 10 shows the matching faces of one of the full-size disks after bursting. Since the disk was 2 in. thick, the size of the thermal cracks, as shown by the darkened areas, is readily evident.

[6] "Bursting Tests of Steam-Turbine Disk Wheels," by E. L. Robinson, Trans. ASME, vol. 66, 1944, pp. 373–386.

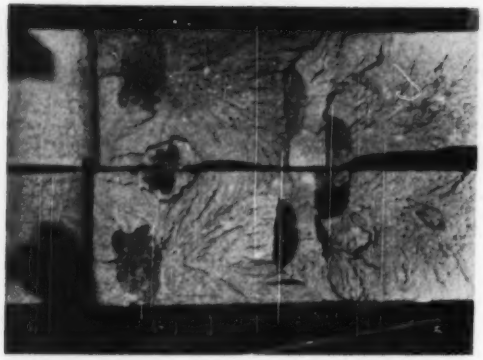

FIG. 10 MATCHING FACES OF A FULL-SIZE DISK AFTER BURSTING
(Darkened areas are thermal cracks. Disk thickness is 2 in.)

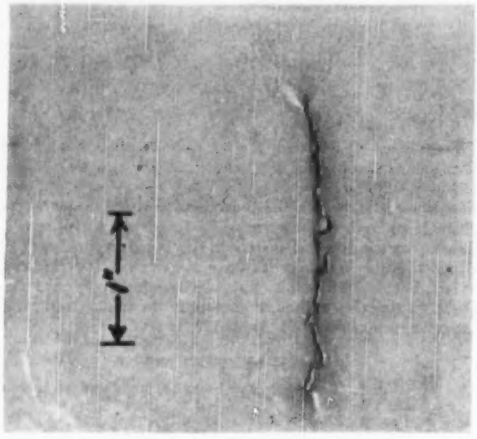

FIG. 11 CRACK IN MODEL DISK JUST PRIOR TO BURSTING
(This crack was invisible without magnetic-particle preparation prior to running of high-speed tests.)

One model disk which was dropped at 93 per cent of its final bursting speed because of a fatigue break in the driving spindle presented an opportunity to observe the crack appearance just below bursting speed. Fig. 11 shows a crack in this dropped disk, and the crack opening is clearly evident. This crack was invisible without magnetic-particle preparation prior to the running of this high-speed test.

Because of the questions which arise concerning possible enlargement of the cracks during the start-and-stop cycles, the repeated overspeed tests at 120 per cent of rated speed were conducted. The results of these tests can be itemized as follows:

1 One full-size disk was run to 120 per cent of rated speed (4320 rpm) for 200 start-and-stop cycles with no measurable change in the cracks. A second full-size disk was run for 100 such start-and-stop cycles with no measurable change in the cracks.

2 One model disk was run to 120 per cent of rated speed (16,000 rpm) for 200 start-and-stop cycles with no measurable change in the cracks. A second model disk was run for 100 such start-and-stop cycles with no measurable change in the cracks.

The foregoing tests indicate that the normal start-and-stop cycles would have no tendency to cause the cracks to enlarge, at least for 200 such cycles.

ACKNOWLEDGMENT

The authors express their indebtedness to the many members of the Laboratory and Engineering Divisions of the General Electric Company who participated in the various phases of this investigation. In particular, they express their indebtedness to the late W. G. Conant, who was in charge of the metallographic studies, and who contributed considerably to the interpretation of the photomicrographs.

Appendix

SURFACE-ROUGHNESS SYMBOLS

General Electric symbol	f1	f2	f3	f3½	f4
Equivalent ASA	4	8	16	32	63
General Electric symbol	f5	f6	f6½	f7	f8
Equivalent ASA	125	250	500	1000	2000

(The equivalent ASA number is the average surface roughness in microinches.)

Power Production

SPEAKING before the AIEE Power Conference held recently at Pittsburgh, Pa., A. C. Monteith, Mem. ASME, vice-president in charge of engineering for the Westinghouse Electric Corporation, pointed out that this country has increased its installed capacity of electrical generation by one third during the five years following the war and will again increase this total by about 40 per cent in the next five years. We are in the midst of the greatest expansion in the history of the power industry, he said, and development of electrical equipment is matching strides with this tremendous expansion.

Steam turbines are increasing in size and in efficiency. The need for high generation efficiency under the influence of rising fuel costs has brought back reheat turbines. Modern reheat turbines either completed or in manufacture by Westinghouse total 12 units with 900,000-kw rating, the largest having 125,000 kw capability.

Sizes of high-speed generating units are increasing. Recently Westinghouse offered to build a 150,000-kw machine using one half pound hydrogen pressure. It is interesting to note that with 30-lb hydrogen, this machine could deliver 220,000 kva.

Switchgear is also advancing to meet the new demands. Only a year ago 5 million kva was considered the probable upper limit in interrupting capacity for 138 and 161-kv systems. One large system is now planning on the basis of 7½ million kva for its 161-kv system.

Transformers continue to grow in capacity. A rating of 145,000-kva for a three-phase transformer already has been reached with possibly even larger ones in the near future.

Liquid-filled transformers will largely disappear from industrial plants and office buildings to be replaced with air or gas-cooled types. Development of a completely sealed, dry-type transformer makes practical elimination of transformer liquids.

Mechanical-Engineering Graduates in the Railroad Industry

IT HAS been reported that the records of any railroad, taken at random, would show that only about ten per cent of college graduates employed remain as long as five years. Therefore, to develop ways and means which would give the greatest practical promise of attracting and holding mechanical-engineering graduates in the railroad industry, the Railroad and Management Divisions co-sponsored a "Symposium on Attracting Mechanical-Engineering Graduates to the Railroad Industry," at the 1949 ASME Annual Meeting.

Condensations of the following three papers presented at the symposium are given:

Through the results of a special survey the first paper evaluates the opinions of educational institutions, their students, and graduates toward the railroad industry, and reveals why there is a laxity on the part of engineering schools to recommend graduates to the railroad industry. On the other hand, two papers, one outlining the special-apprentice course of the New York Central System, and the other describing the student-apprentice system on the Southern Railway, tell what these two railroads are doing for engineering graduates and the many attractions offered to them by the railroad industry, through special training programs.

Educational Institutions, Students, and Graduates

By LAWRENCE W. WALLACE[1]

Attracting mechanical-engineering graduates to the railroad industry is a timely and significant topic and should challenge and command the careful, thorough, and open-minded consideration of all concerned.

There are four primary groups involved: The railroad industry, educational institutions, graduates, and students. It is felt that any consideration which does not include an appropriate evaluation of each of these groups is both incomplete and largely fruitless.

A special survey was conducted by writing to the president, dean, or head of the mechanical-engineering department of at least one technical institution in each of the 48 states. Each was asked to supply information and comments on the employment of engineering graduates in the railroad industry, with the assurance that neither the name of the institution nor the correspondent would be divulged. The responses, therefore, were frank. The number and character of the responses were most informative and gratifying. Some examined the records, held group conferences with staff members and student classes, and conferred with graduates in the railroad industry. Responses were received from 34 institutions representing the opinions of more than 75 individuals.

The consensus of this survey indicated that to attract and permanently retain college graduates in railroad service, substantial improvements will be required in existing policies and practices with respect to (1) relationships with educational institutions, including their graduates and students; (2) methods of recruiting; (3) conditions of employment; and (4) career potentials.

Relationships With Educational Institutions. The audience presented by educational institutions, their graduates, and students is large, intelligent, and influential. In numbers alone it is an important audience, as evidenced by the enrollment in colleges and universities which, in 1947, approximated 2,340,000 men and women. Perhaps the number of staff members, employees, and graduates would make the total audience more than 3,000,000. It is necessary for the railroad industry to reach this audience with carefully prepared and pointed information about its structure.

Four institutions reported they had either materially curtailed or discontinued courses of study with respect to the railroad industry because of lack of interest on the part of the industry and students. There is evidence, however, that these and other institutions would, with appropriate encouragement and collaboration on the part of the industry, refashion existing courses and initiate new ones to fulfill to a greater extent the present needs of the industry.

A substantial and important body of latent good will does exist, but it is being jeopardized by the impression prevailing that the railroad industry is not interested. It is obvious that there is real need for a thorough and forthright public-relations program designed specifically for this large and influential audience. It is equally obvious that to depend entirely upon the daily, trade, and technical press to reach this audience is unwise. It is just as important to reach this audience in terms of the many broad interests and problems of the entire railroad industry, as well as in terms of the employment of college graduates.

Methods of Recruiting. Almost without exception every correspondent commented upon the inadequacy of the recruiting methods of the railroad industry. It was pointed out that the railroads cannot match any one of a number of industrial concerns in the following:

1 A centralized technical personnel department serving the needs of the entire company.

2 Specially prepared information about career opportunities to prospective engineering employees.

3 Conducting interviews in the engineering colleges by a specially trained technical personnel man.

It was indicated that the railroads do not seem to have designated any responsible official to survey their needs and to visit the colleges with a view to selecting qualified material.

Conditions of Employment. Again, almost without exception,

[1] Counselor on Management, Cincinnati, Ohio. Fellow ASME.

Symposium contributed by the Railroad and Management Divisions and presented at the Annual Meeting, New York, N. Y., November 27–December 2, 1949, of The American Society of Mechanical Engineers. Condensed.

correspondents specifically commented upon the conditions and terms of employment. It was clearly indicated that these matters were primary inhibitions to securing and retaining the services of college graduates. Those discussed with greatest emphasis were:

1 Apprenticeships—considered too long and unattractive in terms of value to the man. His technical knowledge and experience are largely wasted.

2 Seniority and Union Regulations—considered positive detriments to advancement and awards on the basis of individual ability and effort.

3 Training—not directed toward correlating graduates' academic training with the needs and opportunities of the industry.

4 Starting and Advancing Scales of Salaries—discussed by all correspondents. Generally, however, as much emphasis was not placed upon this matter as on the conditions of employment. The entire question, should, however, be reviewed.

Career Opportunities. Repeatedly it was said that college graduates were not interested in railroad employment because they felt that there were not sufficient career opportunities. Many reasons were given for this, prominent among them being seniority and union regulations.

It would seem there are no insurmountable difficulties to establishing a strong case that there are promising and desirable career opportunities in the railroad industry. However, such a case will have to be established through pointed and adequate effort. The proper handling of the relationships between the industry and the educational institutions, their graduates and students, would alone be one of the effective means of satisfying ambitious young men and women that there are real, enduring, and challenging career opportunities in the railroad industry.

To attract and retain college graduates in the service of the railroad industry, co-ordinated study should be made of the foregoing problems. This study should not be the effort of one railroad company, however competent, but rather, the co-ordinated approach and action of such an organization as the Association of American Railroads.

Some of the first actions of such a program would be as follows:

1 Place the necessary authority, responsibility, and funds in the appropriate division of the Association.

2 Instruct the Division to establish a thoroughly competent staff the sole duty of which would be to plan, formulate, and supervise the execution of the program.

3 Instruct the staff of the Division that its plans should provide specifically for:

(*a*) Thorough collaboration with all groups concerned with the several phases of the research program, such as agencies within the industry, educational institutions, railway-supply industry, technical, management, and other professional societies, and labor unions.

(*b*) Exploring directions in which college graduates may be used efficiently and effectively with respect to all functions with which the railroad management is concerned.

(*c*) Exploring the directions in which the graduates of junior colleges or their equivalents, and of vocational schools, may be used efficiently and effectively with respect to all functions with which the railroad management is concerned.

(*d*) Preparation, on the basis of the results of the research program, of a recommended course of action with respect to relations with educational institutions, recruiting, employment conditions and terms, and career opportunities.

(*e*) Recommending definite ways and means for continuing such studies, applying the results, and supervising programs installed.

Training and Retaining Engineers by the New York Central System

By F. K. MITCHELL[2]

The Equipment Department of the New York Central System is responsible for the design of electric, steam, and Diesel locomotives; passenger, freight, and work-equipment cars; power plants, shops, shop machinery, and special devices. After the design is completed this department is responsible for the construction of this equipment, and thereafter for its maintenance and operation. Engaged in this task are about 200 men on strictly engineering work and some 2000 men in supervisory positions on maintenance work whose positions the new mechanical and electrical graduate could aspire to. Quite frequently also, Equipment Department engineers and supervisors are transferred to positions in other departments, thus broadening the field of advancement materially.

Since 1901 the New York Central has had a special apprentice course designed to fit the engineering graduate for these positions. Over the years this course has varied considerably, the following final system having been evolved some five years ago:

1 Must be graduate of mechanical-engineering or mechanic-electrical course from an accredited college. Some practical experience desirable, but may be waived. Interview required.

2 Age—under 26. Good physical condition, sight, and hearing, and good moral character. Must have an earnest desire to enter training course

3 Course is three years. Consists of experience on the regular work in the shops, engine terminals, and repair yards, with a change as nearly in accordance with the program under Paragraph 4 as circumstances permit.

4 Training schedule for special apprentices. Those assignments shown in the first and second years are required, but the order of the assignment may be changed as conditions make necessary, although the order shown is considered to be the desirable sequence:

First Year—Locomotive Shops; three months each on the erecting floor, machine shop, boiler shop, and blacksmith shop.

Second Year—Three months each at passenger-car shop, freight-car shop, electric shop, and Diesel-electric shop.

Third Year—First six months:

Optional assignment to engine terminal, passenger, or freight repair yard.

Third Year—Second six months:

Special assignment with one of the following, including filling of temporary supervisory vacancies, selection to be made in joint conference with student and management: Supervisor of

[2] Manager of Equipment, New York Central System, New York, N. Y. Mem. ASME.

Locomotive and Fuel Performance; Engineer of Tests; Engineer of Motive Power, Rolling Stock, or Electrical Equipment; Master Mechanic; Division General Car Foremen; or Shop Superintendent; either Locomotive, Car, or Electric Shop.

Those special apprentices who prior to starting their special apprenticeship have served time as regular apprentices in any of the shops or capacities outlined, will be credited for such time on the basis of the number of days actually spent on the work involved.

5 No pay for overtime allowed. Refund for expenditures when on detached duty is permitted. Two weeks vacation per year, with pay, is allowed, after the first year.

6 Rate of pay

	First six months	Second six months
1st Year	$277.50	$285.50
2nd Year	293.50	301.50
3rd Year	309.50	317.50

7 At completion of the course, permanent assignment will be made to a place which the graduate can fill for the best interest of the company and with credit to himself.

Interviews with and the hiring of engineering graduates are handled by either the manager of equipment or the general superintendent of equipment. The number of special apprentices on the rolls at any one time is held to not over twenty five. It is evident, therefore, that there is a broad field for the graduate from this course. To insure uniform training and a close observance of the progress of the special apprentice his assignments are controlled by the General Superintendent of Equipment at New York. His immediate superior during any one assignment is required to make a monthly report of his progress and capabilities to the general superintendent of equipment.

The special-apprentice course, which consists of three years, imposes the heaviest physical work load on the student right at the start. He is required to actually perform work with regular mechanics and there is no attempt made to make things easy for him. His course is varied each three months during the first two years. Therefore his interest is never allowed to lag. The same is true during the first half of his last year on the optional assignment where he works and learns the running repair methods and requirements on locomotive or cars.

When the first six months of the third or last year of the special apprenticeship has been satisfactorily completed, the student is called in for another conference. The purpose this time is to review his progress and experience, ascertain his preferences, and jointly decide on his assignment for the last six months of the course. This is considered an important phase in the student's education. By now he has had opportunity to see for himself what the maintenance problems are on all types of equipment, to learn the work and production methods followed, and to establish to his own satisfaction which type of work he is best qualified for and will be most satisfied with. Also management has learned his limitations, his capabilities, and natural bent.

The student mechanic now becomes a student supervisor. He carries out special engineering and managerial assignments given him by the officer to whom assigned, and starting in a small way on supervisory jobs of minor importance begins to obtain experience in handling men. As he progresses the importance of these assignments become increasingly greater, as do the responsibilities he is allowed to assume.

For approximately a year after the course is completed, his assignments are on jobs primarily of an instructive nature. They cover essential work, but of educational nature. The rates of pay are high enough to be an attractive promotion over the rate paid during the last year of the special-apprentice course.

At the end of this period, usually about the end of the fourth year of his employment, he takes a place in the ranks of the supervisors or the engineering staff as his capabilities and desires indicate him best fitted for. He now must take his chances of promotion along with the 2200 other supervisors and engineers.

Where he goes, the heights he attains, is a matter which he knows is entirely up to him and the way he handles each succeeding position or job with which he is entrusted. He knows also that there is no limit except that imposed by himself as to the height he can climb during his railroad career.

Why then, should there be any reason for him to leave the service of a company which has devoted so much time and money to his education and which offers so great an opportunity to him for his future? The answer to this question may be found by a search of the records and case histories of those who have entered New York Central service as special apprentice.

Between 1901 and 1920 but few special apprentices were employed. The highest number per year was three and in many years none were employed. During that time the value of the special apprentice to the railroad company evidently had not been thoroughly established. Neither had a good special-apprentice training program been worked out. Much of the hiring was apparently done on the basis of family connection and the placement of these men depended largely on their acceptance by the few men in authority who were convinced that the railroad company needed engineering graduates for any jobs other than strictly academic engineering work. On the other hand, in spite of these facts, some very fine engineers began to receive recognition and make a place for themselves. As a result, the attitude toward employment of men with an engineering background gradually changed.

During the next ten years, 1920 to 1929, the average number of special apprentices graduated was about seven per year and a peak of 14 was reached in 1923.

The depression in business which followed not only stopped the hiring entirely, but resulted in a large number of former special apprentices either being furloughed, dropped from the rolls entirely, or resigning because of the uncertainty which continued lay-off and salary reductions created.

In 1934, with business improved and conditions generally more stable, engineers again began graduating from the special-apprentice course and for the next eight years, 1934 to 1941, the number graduating annually averaged $5^1/_2$ with a peak of eight. During the same period, however, eleven special-apprentice course graduates severed their connection with the railroad primarily because of there being a disparity of rates of pay between those offered by the railroad company and those paid by other industry. Furthermore, the special-apprentice training course then in effect was neither thorough nor attractive and the practice of furloughing them when business was bad was discouraging.

Then followed the war years, during which it was practically impossible to hire a young man because of military requirements. During their military service a large number of those who had not finished their special-apprentice courses were married and by the time the war was over had obligations which no longer made the rate of pay for special apprentices attractive to them. Consequently few returned.

While these reverses were being suffered the Central's officials were studying the situation carefully, and through that study realized that they must do the following: (1) Make the hiring rates for special apprentices more attractive, (2) improve employee relations with the special apprentices, (3) improve the

training course, (4) improve their chances of advancement, (5) avoid lay-off of these men if at all possible during lean times, (6) not overhire so that good jobs would be available to those who qualified for them, (7) minimize the necessity for moving the apprentice from one point to another and compensate him for his moving expense when it became necessary to move him, and (8) make him a part of management from the time he was hired.

The present system and training course was devised and went into effect at the close of the war. The results thus far have been highly satisfactory. Since the war 24 young engineers have been graduated and taken over good positions. Nineteen undergraduates are being trained and their prospects of advancement after graduation are good. Furthermore, there are numerous applications on file from which to fill our requirements and new applications are coming in currently.

Since putting the new system into effect the retention rate is approximately 80 per cent.

Student-Apprentice System on Southern Railway

BY J. B. AKERS[a]

The Student Apprentice System on Southern Railway System lines was a result of difficulties experienced in the selection and training of men for positions of officers from track supervisor and trainmaster to the highest positions. In the earlier years gang foremen were promoted to the positions of track supervisor and bridge and building supervisor, and then to roadmaster (division engineer now); train conductors and dispatchers were usually promoted to positions as trainmaster and subsequently to superintendent and higher positions.

It was recognized about 1912 that this system would not produce sufficient men for the future nor would it take into consideration any educational training which then seemed desirable.

Accordingly the Student Apprentice System was adopted and the first class of such men was employed in 1914. The idea was to select young men just out of college who had an engineering degree. A number of men were assigned to these training positions, but it was discontinued during the first World War.

The training course was taken up again in an active way in 1925 and practically all of the development of this system has been since that time. It has been increasingly evident that it was a wise course to adopt in order to procure men for such advancement.

There are now 104 men employed who have passed through the training course and occupy official positions. There are 19 men in the training course.

The preference is for those graduates who have displayed some mark of leadership in college, such as president of a debating society, captain of some athletic team, editor of the college paper or magazine, or, in fact, anything which would give the man some distinction. Men who were raised on a farm would be given some preference. A number of the colleges and universities have an understanding of our system of training and will suggest men to us and recommend the employment to them.

These men are placed in service with a section force under a selected foreman. Here he will learn the day-to-day maintenance work of smoothing rough places, gaging track, adjusting switches, and the like. Next he is placed on an extra gang where heavy work is done, such as rail laying, ballasting, construction of new tracks, and ditching. He is then placed on a bridge and building gang where he will have an opportunity to learn how to handle and frame structural timbers, get an idea of the conditions that must obtain for safety, smoothing trestles, patching in timbers, and care of steel structures.

After service of a year or more he is given a course which will consume several months in other departments. In this particular part of the training he will spend sufficient time in a freight agency, with a trainmaster, with a division freight agent or other traffic officer, in the personnel office, and in the mechanical department.

The intention is that in these months the apprentice will get a broad background of what is required in railway service in other departments.

Apprentices in training are required to write full papers on the work they encounter in departments to which assigned. These papers reflect their understanding of the work.

The apprentices described are in the maintenance of way department. The title "Engineer in Training" is intended to cover men who are still in college, but who wish to work on the railroad during the summer months. At present these men are paid $200 per month which is the approximate pay of a section laborer. When they are taken on as student apprentices the entry rate is usually $250 per month. After some months the men are promoted to the rank of assistant supervisor, but still in the apprentice training program. In this class of service the rates of pay may be anything up to $370 per month. While they are assistant supervisors (in training) they will be assigned to some track supervisor or bridge and building supervisor where they will observe work being done, hear instructions given by the supervisors, and have an opportunity to discuss them in connection with the actual work being performed.

After the apprentice has served a suitable length of time and has reached a point where it is considered desirable, he is promoted to the rank of track supervisor or bridge and building supervisor. After he reaches these positions, further promotion is dependent altogether upon merit. Ordinarily it will consume about three years for a student apprentice to reach the position of tract supervisor. His later promotion may be in the Maintenance of Way Department or in the Transportation Department. If he goes into the Transportation Department he is usually made an assistant trainmaster.

No difficulty has ever been experienced in the employment of student apprentices with employee agreements. There is an understanding with the maintenance-of-way organization that permits these men to work and use such tools as any laborer does. There is a provision that the employment of student apprentices will not reduce the number of laborers that would otherwise be employed.

The training course is such that men may be transferred from the Maintenance of Way Department to the Transportation Department, or vice versa. When this is done best results seem to follow. The training program has provided a suitable and satisfactory reservoir of men who are eligible for promotion and available at any time. Another desirable result is that the positions are now filled by men of moderate age. A great many of the men now occupying positions as division engineers and superintendents are about 40 years of age.

[a] Chief Engineer, Southern Railway System, Washington, D. C.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

Compiled and Edited by J. J. Jaklitsch, Jr.

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

Atomic Energy

Revised Research Program

EXTENSIVE revision of the research program of the Knolls Atomic Power Laboratory, Schenectady, N. Y., to provide for maximum participation of the Laboratory technical staff in an expanded atomic-energy-production program at the Hanford Works, Richland, Wash., and to speed up design and development work on a land-based prototype for a ship-propulsion reactor has been authorized by the Atomic Energy Commission.

The Commission's authorization follows recommendations of the General Electric Company, whose Research Laboratory operates the Knolls Atomic Power Laboratory, as to the best method of using KAPL man power in speeding up the over-all atomic-energy program, in accordance with program goals set by the Commission.

The reorientation of the KAPL research followed a Commission action deferring the start of construction of the West Milton intermediate power-breeder reactor project, upon whose design KAPL has worked along with preliminary design of the ship reactor. It is estimated that from two thirds to three fourths of the research and development work already done on the intermediate power-breeder reactor will find use in the accelerated ship-propulsion-reactor project.

The Ship Intermediate Reactor (SIR) is a second and simultaneous attack by industrial contractors of the Commission on the problem of applying atomic energy to naval ship propulsion. The Argonne National Laboratory and the Westinghouse Electric Corporation are developing designs for a land-based prototype of a Ship Thermal Reactor (STR) suitable for naval ship propulsion. Although both reactors will be designed to meet similar Navy performance specifications, they will be separate projects, involving different approaches and therefore different technical and engineering problems.

The plans for the SIR will call for a single-purpose machine designed specifically to produce large amounts of heat to be used for generating power. This is the difference between the SIR and the original West Milton power-breeder reactor. The latter was designed both for power production and for breeding reactor fuel. The two naval reactors will contribute considerable amounts of data and operating experience which should prove invaluable in the development of future reactors for the production of power for commercial use.

The General Electric Company has been authorized by the Commission to proceed immediately with the revised research and development program. The first step is to get engineering design work in shape to make firm cost estimates for the SIR project. After approval of reactor design by the Commission it is presently planned that the land-based prototype will be authorized for construction on a site near West Milton, N. Y. As much as possible of this work will be done on a competitive price basis.

Geiger Counter

An inexpensive Geiger counter designed to measure high levels of radiation has been developed by the instrument laboratory of the New York Operations Office of the U. S. Atomic Energy Commission for civilian use.

The new instrument is powered by three $1^1/_2$-volt flashlight batteries. It weighs slightly under $2^1/_2$ lb and is housed in a moistureproof aluminum case consisting of two aluminum cylinders, one holding the flashlight batteries and the other containing all the working parts of the counter.

No field calibration of the instrument is necessary, and its dial reads directly in roentgens per hour, the basic units of radiation measurement. The dial is divided into three color zones: green, from 0 to 0.1 roentgens per hr; yellow, from 0.1 to 1.0 roentgens per hr; and red from 1.0 to 5 roentgens per hr.

It is estimated that if the new instrument were put into large-scale production it probably could be sold commercially for from $10 to $15.

The new instrument uses a halogen-filled Geiger tube, specially designed by Amperex Electronic Products Company, Brooklyn, N. Y., which delivers between 50 to 100 times the output current of conventional tubes. For this reason, no amplification of the tube's pulses is required.

How to Obtain Further Information on "Briefing the Record" Items

MATERIAL for this section is abstracted from: (1) technical magazines; (2) news stories and releases of manufacturers, Government agencies, and other institutions; and (3) ASME technical papers not preprinted for meetings. Abstracts of ASME preprints will be found in the "ASME Technical Digest" section.

For the texts from which the abstracts of the "Briefing the Record" section are prepared, the reader is referred to the original sources, i.e.: (1) The technical magazine mentioned in the abstract, which is on file in the Engineering Societies Library, 29 West 39th St., New York 18, N. Y., and other libraries. (2) The manufacturer, Government agency, or other institution referred to in the abstract. (3) The Engineering Societies Library for ASME papers not preprinted for meetings. Only the original manuscripts of these papers are available. Photostat copies may be purchased from the Library at usual rates, 40 cents per page.

Air Filter

A new inexpensive paperlike filter material designed for filtering fine radioactive particles from contaminated gaseous wastes has been developed for the Atomic Energy Commission by Arthur D. Little, Inc., Cambridge, Mass. The development may have general commercial or industrial use, for instance, in filtering the smokestack gases which now cause fumes or smog.

The new material contains treated papermaking fibers in combination with finely divided mineral asbestos fibers. The material is made in soft, flexible sheets which can be pleated and formed into shapes to fit filtering units of large capacity.

The paper can be made on relatively slow Fourdrinier machines of a type found in a large number of paper mills fabricating soft saturating papers. Thus the atomic-energy program can be assured a diversified source of supply.

The filter units consist of deep closely spaced pleats of filter paper fitted into wooden frames. The pleats are spaced and kept in line by deformed separators of ordinary paper which hold them in place and permit easy passage of the air to be filtered. The paper pleats and separators are anchored into wooden frames with plastic adhesives. The frames are in turn glued and screwed at all corner joints to produce a perfectly tight assembly. Gaskets of soft sponge rubber cemented around the edges of the frames prevent air leaks when the frames are clamped into place.

Uranium Exploration

The Atomic Energy Commission is looking to the private prospector and the mining industry to assure the success of our uranium-exploration program, according to an address by P. L. Merritt of the AEC, before a recent meeting of the Canadian Institute of Mining and Metallurgy. Industry is certain to increase its activity in the field rapidly as the economic importance of uranium to its operations is more fully realized. The contribution made by educational institutions and by other government agencies in developing and distributing information is recognized by the Commission as an important phase of the program.

Progress is being made in the discovery of ore and the development of ore-finding techniques on the Colorado Plateau, which is the most important uranium-producing region in the United States. Other areas of primary and secondary uranium mineralization, such as the Colorado Front Range, the newly discovered deposits in the Sunshine Mine in Idaho, the Marysvale, Utah, area, and the Upper Peninsula of Michigan, show promise for future production. Evaluation of potential low-grade uranium ores such as the phosphate rocks of Florida and the northwestern states and the black shales of Tennessee and Kentucky, has been substantially completed.

The Commission's exploration program will, it is believed, assure the United States of a growing supply of domestic uranium ore. Together with the results of the Canadian exploration activities, which are most encouraging, the program should provide increasing resources of this all-important material, and should further reduce dependence on supplies from overseas.

Training Programs

The first ten technical graduates have reported at Hanford Works in the State of Washington, to begin the newly installed General Electric Company rotational training program, believed to be the first program of its kind at any U. S. atomic-energy plant.

According to D. W. McLenegan, Mem. ASME, of the Technical Personnel Office at the plutonium manufacturing plant, approximately 50 promising young technical graduates at a time ultimately will receive training through this program.

Technical graduates recruited for the newly installed rotational program at Hanford Works will spend three months each on successive assignments in different parts of the Washington installation so that they can get acquainted with the plant's operation and the plant can get acquainted with their aptitudes.

Automation

HOW automation—the automatic handling of parts in production without physical effort by the operator—has been applied to the production of 3,000,000 valve guide bushings for Ford V-8 engines per month, was detailed to members and guests of the American Society of Tool Engineers at its recent meeting in Philadelphia, Pa., by N. L. Bean, Mem. ASME, Ford Motor Company, Detroit, Mich.

According to Mr. Bean, only once in the entire production line are the bushings touched by hand.

The bushings arrive at the bushing department in bins from the foundry and are dumped into a hopper. The castings drop out of the hopper one at a time onto a moving belt which carries them up an incline to a battery of centerless grinders. Here they are dumped into another hopper from which they move in a continuous stream through the first grinder, a second, and a third, gradually bringing the outside of the bushing to required size.

As they come out of the grinders, the bushings fall onto a moving belt which dumps them onto a wire-mesh conveyer carrying them through a washing tunnel. Cleaned of grinding compound and grit, they drop onto another belt taking them to a battery of automatic screw machines, which perform four operations each: Turning the small outside diameter, drilling and reaming the bore, and facing and chamfering the end.

Each of these machines has its own hopper with a feed gate. When the hopper is full the gate closes automatically so that the bushings cannot drop off the belt but travel to the next machine's hopper, and so on.

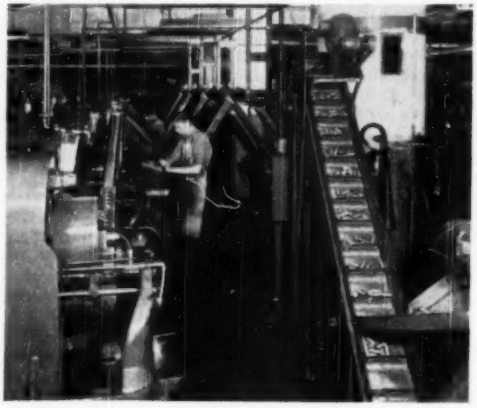

FIG. 1 AUTOMATIC SCREW MACHINES

(Five of the automatic screw machines where bushings are turned, drilled, reamed, and chamfered automatically. The inclined conveyer at right supplies hoppers of all the machines.)

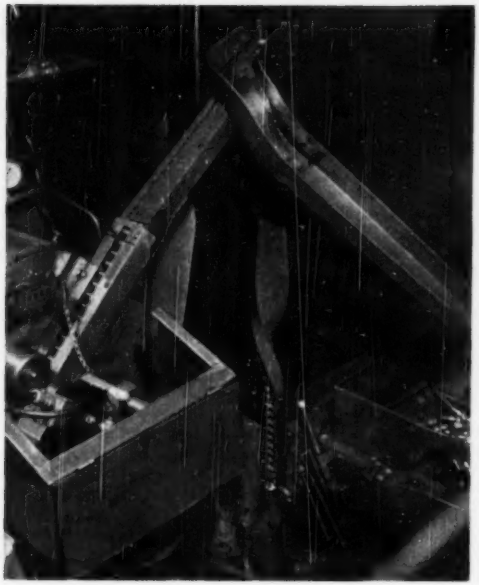

FIG. 2 VERTICAL TWISTING CHUTE

(Bushings are pushed in an upward direction in this vertical twisting chute, where they are permitted to roll into a vertical magazine. When the magazine is filled, the overflow falls into a chute and is returned to the original operation.)

As a bushing drops out of the bottom of one of these hoppers it is pushed up a twisted vertical chute by a plunger, each part pushing the part ahead of it. When the chute is full, additional bushings just drop back into the hopper through a by-pass. The chute feeds the bushings through the machine spindle into machining position one at a time—where they are automatically clamped and machined. The next bushing kicks the "finished" one onto one of two rubberized (to prevent damage) belts. Half of the bushings go onto one belt, half on another. The first belt takes its bushings to another automatic machine to perform further operations required on the bushings for the exhaust valves.

The exhaust bushings are fed into this machine by first dumping them into a hopper bin near the floor. From this bin an inclined conveyer takes them up to a selecting hopper under the ceiling which selects the bushings, turns them right end up, and drops them into one of two chutes at the proper rate of speed. These chutes are shaped like a "horsecollar" and are actually referred to by that term.

Again the bushings are fed into and out of the machine (when finished) by cam-operated plungers. They drop onto another conveyer and meet the intake-valve bushings at the finish-grinders. They are not mixed, however, the intake bushings going through one group of grinders, the exhaust bushings through another.

As they drop out of the grinder they fall into wire baskets designed so that rubber bumpers check their fall and let them drop gently the last few inches.

At this point a manual operation is finally required. It consists of picking up the full baskets and setting them on a conveyer which takes them through another washer. As they come out of this, a monorail conveyer picks up the baskets and transports them to the precision-boring machines. Here they are placed in hollow tubes through which they are fed into and out of the machine. Locating of the parts in the machine (with locating plungers—vertical and horizontal) and machining is again automatic.

An interesting thing about these machines is that they do not machine the bores "as smooth as possible." Rather, the surface produced inside the bushing is purposely made slightly "rough" for better lubrication in service.

The machines are said to be so accurate that no gaging is required. To make certain, however, each bushing is passed over a rotating reamer—by hand. If the reamer tries to turn the bushing slightly in the operator's hand, it is correct. If the bushing just slides over the reamer without trying to turn with it, it is rejected as "oversize."

This, the only real manual operation in the entire line, may also soon be "automatized." Ford is working on a device which will measure the "tendency to turn" to an ounce-inch. This device will make it possible to automatically pass or reject bushings.

As many as 127,600 bushings have been produced in two 8-hr shifts—a rate of better than 132 per min.

AUTOMATION IN FORGE PLANTS

Use of automation is also entirely feasible in forge plants despite the large weight of the parts and the high temperatures encountered, Thomas E. Darnton and Willard L. Mantz of the Oldsmobile Division, General Motors Corporation, Lansing, Mich., pointed out during the same meeting.

Although automation is commonly associated more with machining plants, some 250 different types of forgings in quantities totaling over one million pounds per day are now handled with a minimum of manual effort in Oldsmobile's forge plants, through the use of such devices as magnetic cranes, power conveyers, some 35 "finger" trucks which pick up and transport parts, overhead monorail conveyers—some more than $^1/_4$ mile in length—automatic furnaces for heat-treating, slat conveyers, and even the old block and tackle.

Some of the parts, such as crankshaft billets, have to move along on these conveyers while heated to around 2300 F. Ability to handle such parts mechanically of course greatly improves working conditions in forge plants.

Some of the automatic furnace installations operate without requiring any manual handling of the work while handling approximately 100 crankshafts per hour. The same is true for washing installations for forgings and pickling baths.

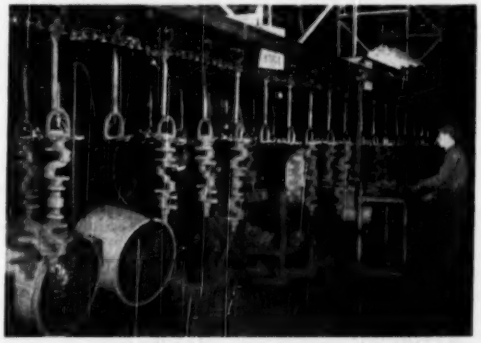

FIG. 3 THIS 15-FT MONORAIL CONVEYER CARRIES CRANKSHAFTS ON ALLOY HANGERS FROM THE DRAW FURNACE THROUGH A WATER-COOLING TANK TO BRING THE CRANKSHAFTS TO ROOM TEMPERATURE

AUTOMATIC ASSEMBLING OF PARTS

Striking cost-cutting possibilities of using automatic machines to assemble parts instead of using manual labor were also outlined at the ASTE meeting, by Herman Zorn, president, V & O Press Company, of Hudson, N. Y.

He described how various parts can be first automatically formed in presses and then assembled with other parts fed into the machines by transfer devices, hoppers, or the like. In this way certain subassemblies of manufactured products, he said, can be turned out completely automatically. The raw material, such as strip steel, can be fed automatically into one side of the press and the assembled unit comes out of the other side, as many as 12 or 15 operations having been performed in between.

In some cases the movement of an operator's hand is duplicated by a "mechanical hand" which has either fingers or a vacuum cup to pick up the part, move it into place in the machine, and release it there. Such hands do not necessarily eliminate the operator but make his job easier and far safer since it keeps his own hands away from the machine.

COMPLETE MECHANIZATION FAR OFF

C. E. Kraus, Mem. ASME, president, Kraus Design, Inc., Rochester, N. Y., however, discounted recent forcasts that the day is rapidly approaching when all kinds of products can be turned out without any manual handling.

Complete mechanization of plants, where raw material is dumped into an automatic line at one end and the finished product comes out of the other ready to ship to the consumer, is theoretically possible or practicable in only occasional instances, he said.

Advocating the principle of making haste slowly, Mr. Kraus admitted that vast cost reductions in the manufacture of all kinds of products are possible with better materials handling. However, he pointed out, the investment cost in the equipment required may in many cases far more than offset the savings in manual effort.

Even in feeding a part into a machine, he explained, the sorting mechanism may be extremely complex. Only a ball, he said, can be fed into a machine without its ever being "wrong end to." On the other hand, there are seven wrong ways and only one right way in which some rectangular parts can enter a machine. This means that automatic sorting mechanisms must first arrange the parts according to one direction, then another, and a third, and so on.

Nevertheless, he urged tool engineers to concentrate on studies of automatic handling mechanisms. Experience in using and maintaining such equipment must be developed, he pointed out, just as experience in operating any other kind of high-production tools. While some of the simpler hoppers can be applied almost anywhere, experience becomes more and more essential as complications increase.

Automatic materials-handling mechanisms may in many cases serve to cut initial investment for new machines, however, he pointed out, since they sometimes permit a few machines operating more efficiently to do the work of the many otherwise required. In some cases simple loading devices on a single machine have doubled and tripled production by making the job easier for the operator, he added.

World Tanker Fleets

ALTHOUGH world trade as a whole has barely returned to prewar levels, petroleum shipments have increased tremendously, it is pointed out in an article in the April, 1950, issue of the *Industrial Bulletin* of Arthur D. Little, Inc. When construction in progress or on order is completed, merchant shipping tonnage will be 13 per cent above prewar levels, almost entirely because of a 74 per cent rise in tanker tonnage since 1939.

According to the *Bulletin*, including current construction, the world's tanker fleets total 31 million dead-weight tons, of which about nine million are American. Tankers make up half the active U. S. merchant fleet, the world's largest. Great Britain, whose control of about a fifth of the world's shipping puts her second in total merchant tonnage, has about 20 per cent in oil carriers. Britain's shipyards, which are turning out 45 per cent of the world's new vessels, have a little more than half their tonnage of new construction in tankers. The smaller shipbuilding industry of the United States has about 90 per cent of its tonnage on order in tank ships; these are mainly responsible for changing the low level of activity early in 1948 to the shipbuilding pace which made 1949 a record peacetime year.

Tankers, which have long been among the largest and fastest of ocean freight carriers, now tend to be even larger and faster, with the U. S. ships generally the leaders in size and speed. Although deeper drafts restrict the large tankers to fewer ports, increased costs of shipbuilding and operating justify them. On the basis of cost per deadweight ton, larger ships are less expensive to build than smaller ones, and a 28,000-ton tanker can be operated with nearly the same crew and staff as a 12,000 or 15,000-ton ship. Furthermore, as the water-line length increases, the most efficient cruising speed also goes up. The so-called super tankers now being built here are generally designed for 16 to 17 knots, and range from 25,000 to 30,000 dead-weight tons, with 35,000-ton tankers under consideration. In 1949 the U. S. completed 33 tankers averaging 26,000 dead-weight tons apiece. A typical modern American super tanker is bigger than the average passenger liner, with an over-all length of about 625 ft, and a beam of over 80 ft. It carries almost a quarter of a million barrels of oil, enough to heat 6500 average homes for a year. Many of these ships have pumps capable of stripping the holds in only 10 to 12 hours.

Construction has now overcome the shortage of tankers which resulted immediately after the war from the rapid rise in the demand for oil. Crude-oil production abroad is at its highest level in history. Since 1948 the United States has been a net importer of oil, with gross imports of 640,000 bbl a day during 1949. In February, 1949, shipments of Middle Eastern crudes reached a peak of about 170,000 bbl a day, about as much as received from Venezuela, usually our principal foreign source. Virtually every other industrial nation, except Russia, has long depended on foreign supplies.

Europe, which once drew most of its supplies from the Western Hemisphere, mainly from the Caribbean area, is now taking its increased supplies of oil from the Persian Gulf ports. Before the war, imports from the West were at the rate of about 580,000 bbl a day; this has been cut almost in half and indications are for a continuing decline. The sterling areas attempt to obtain as much of their supplies as possible from wells controlled by British interests, leaving American-controlled production to find markets elsewhere. An effort is being made, with the aid of Marshall Plan funds, to construct enough refining capacity in Europe to take care of her entire needs. This will be in the neighborhood of a million and a quarter barrels a day, using chiefly Middle Eastern crudes. This oil has a price advantage over Venezuelan or Texas crudes not only in Europe, but also in Chile and Argentina, despite the longer haul from the Middle East. From Ras Tanura in the Persian Gulf to Southampton is 6200 miles, compared with 3900 from Puerto la Cruz, Venezuela. For tankers which can load at the eastern end of the Mediterranean from the pipe lines bringing oil across Arabia (1100 miles) and Iraq (530 miles), however, the tanker

journey is about 3000 miles shorter and the Suez Canal toll charges of 12.5 cents a barrel are avoided. From Ras Tanura to New York is 8300 miles, which limits a tanker to a little over six round trips a year, but even so, under some conditions, Middle Eastern oil may be competitive with Venezuelan and Texas crudes in East Coast ports of the United States.

Heat-Treating

IN terms of use, the average American motor vehicle of today is worth from two to four times as much as the average car of 1925, according to *Automobile Facts*, April, 1950. Its life span, in years, has been doubled; in mileage, it is four times as durable.

This gain in value is due largely to the advances made in metallurgy, the article states.

One phase of the art is the technique of heat-treatment—the controlled heating and cooling of metal under a particular set of conditions to achieve a definite result.

It has been a major factor in adding longer life, greater durability, and better performance to today's cars.

Recently the automotive industry has developed a number of special-purpose machines and corresponding techniques for heat-treating such parts as gears and pinions. These need additional carbon in order to resist the abrasion, erosion, shock, and impact that they are subjected to when the vehicle is in use.

Formerly, carbon was added by heating the machined parts in contact with charcoal, charred bone, charred leather, or bituminous coal. This process has been modernized and mechanized through the use of gas.

A specially designed muffled furnace, 40 ft long, in which the temperature is held at 1650 F, is used.

The oven is filled with natural gas under pressure sufficient to force out all oxygen and prevent the gas from igniting. Parts move automatically into the oven in 19-min intervals. They pass through a series of compression chambers, each with an automatically operated door.

The gas pressures in these chambers are graduated so that the pressure in the oven is maintained at a constant when the intervening doors are opened. A similar set of decompression chambers serves the exit side of the oven. The parts travel the length of the furnace in $10^1/_2$ hr, emerging with the required surface content of carbon.

Another important heat-treatment process is used to increase the tensile strength of automotive parts, such as steering arms and knuckles, that have to absorb shocks and fatigue. To give required strength to these parts, electrically heated furnaces are used. Subjected to heat up to 1550 F, for $2^1/_2$ hr, the forgings are quenched in oil, reheated in another furnace at a lower temperature, and then cooled in air. Every step of the sequence calls for close control of temperatures, for the purpose here is to increase the strength by changing the internal structure of the steel.

Still other forms of heat-treatment are used. One of the simplest is normalizing in which the internal structure is brought back to "normal" after cold-working or heating. This is done by heating to specified temperature and cooling in air.

Annealing, another carefully controlled heat-treatment, is used to soften steel by relieving internal stresses caused by rolling, drawing, or forging.

Tempering, sometimes called drawing, is a form applied to hardened steel, either to regulate the hardness, to toughen it, or to free it of internal stresses.

For parts that require an extremely hard surface, the nitriding process is used. A common method is to heat the parts in a closed container filled with a gas containing active nitrogen until the desired amount of nitrogen has been absorbed in the steel.

When it is desired to add both carbon and nitrogen in the surface of the steel, the heating is done in a bath containing sodium cyanide, calcium cyanide, or calcium cyanamide. This is called cyaniding.

Carburizing, nitriding, and cyaniding fall into that division of heat-treatment called case hardening. They are used to put a hard wear-resistant "case" on a part without changing its internal structure.

These processes are, therefore, largely responsible for the modern motor vehicle's longer life and greater mileage.

Thickness Gage

AN electronic thickness gage for measuring the thickness of nonconducting coatings on nonmagnetic metals has been developed by Charles C. Gordon and Joseph C. Richmond in a project at the National Bureau of Standards sponsored by the National Advisory Committee for Aeronautics. The new instrument provides a simple, direct, nondestructive measurement. These measurements have become important with the increasing use of ceramic materials as protective coatings for metals and alloys in high-temperature service. The new electronic gage can be used with nonmagnetic high-temperature alloys on which magnetic thickness gages cannot be used.

The instrument consists essentially of a small probe coil, an inductance indicating system, and a device for positioning the coil and measuring its distance from the test surface. The probe coil is housed in a cylindrical plastic test head. A small plastic rod attached to a dial indicator extends axially through the coil to serve as a feeler element. The test head is mounted in a heavy gage stand which provides for controlled movement of the test specimen with respect to the probe coil. The electronic components of the 500-kc oscillator and the bridge-type inductance indicating system are housed in a small cabinet and connected to the test head by a removable shielded cable. Bridge balance is indicated by a sensitive galvanometer. The measurement is based upon the change in inductance of the probe coil due to the proximity of the coated metal surface. This change may be visualized by considering the combination as a transformer with the probe coil as a primary coupled to the metal surface as a short-circuited secondary. The inductance of the primary varies with this coupling and hence with the proximity of the metal surface.

The instrument thus relies on the maintenance of a fixed distance between the probe coil and the metal surface whether the ceramic coating is present or not. The coating material has a negligible effect on the electric field at the frequency used; the metal surfaces are similar so their electrical properties are nearly identical. Under these conditions, if the inductance of the probe coil is the same in both cases, the separation distances will be equal and the dial-gage reading will give an accurate value for the coating thickness.

The ceramic thickness gage is designed to measure coatings up to 0.090 in. thick. For thin coatings, where the coil is within 0.020 in. of the metal surface, the sensitivity of the inductance bridge is about the same as the reproducibility of the mechanical dial-gage reading. In this case the thickness indicated on the dial gage is correct to within about 0.0002 in. When the coil is 0.10 in. from the metal surface, readings may, however, be in error by as much as 0.001 in.

Although the instrument was developed primarily for the measurement of the thickness of ceramic coatings on turbine

blades and other high-temperature parts of aircraft power plants, it should be generally useful for thickness determinations of paint, plastic, and other nonconducting films on aluminum, brass, copper, stainless steel, and other slightly magnetic or nonmagnetic metals.

Rubber in Compression

STRESS relaxation in compression is a major factor governing the service life of rubber in many applications. A tester and a test procedure have been developed in the laboratory with which it is possible to measure this property with reasonable speed and accuracy. With this tester a research program has been conducted in which the effects of polymer as a function of the variables of temperature, degree of formation, sample shape and size, and sample slippage have been investigated.

The testing equipment, test procedure, and the results of this program were reported by J. R. Beatty and A. E. Juve, B. F. Goodrich Research Center, Brecksville, Ohio, at the 1949 ASME Annual Meeting.

The authors pointed out that vulcanizates of rubber and synthetic rubber find wide and useful applications under conditions of compressive stress in gaskets, seals, suspension systems for vibration isolation, and other uses. In some of these applications the rubber is subjected to a load, either static or dynamic, or a combination of both. In other cases the compression strain is constant and the stress resulting therefrom is utilized as a seal for fluids or gases. It is with this second application of rubber in compression that this work is concerned.

In the use of rubber under compression as a seal, the service life is dependent on maintaining a value of stress above a minimum which is necessary for the seal to be effective. It can readily be seen then that some method of evaluating materials with respect to service life is highly desirable. Compression set tests, ASTM D-395-47T, method A or B, dependent on the service conditions, have been widely used for some time in evaluating rubber materials to be used in compression. However, this test does not give an answer which is directly applicable as to units, and the test time usually used is too short.

More information was desired on the various commercially available polymers and the effect on the compression stress relaxation of these compounded polymers of a wide temperature range, various degrees of deformation, and some variations in composition. In addition, before investigating these variables it was necessary to determine the effect of sample shape and slippage on stress relaxation. The latter two factors would influence the choice of sample or sample construction.

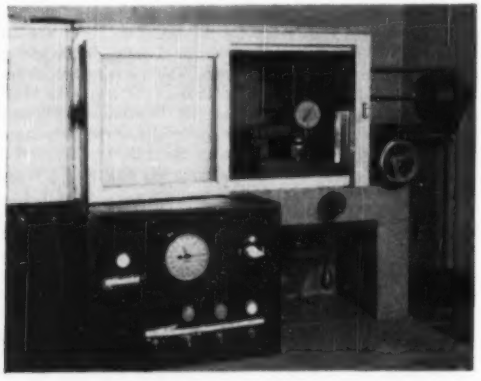

FIG. 4 EQUIPMENT USED FOR STRESS-RELAXATION TESTS

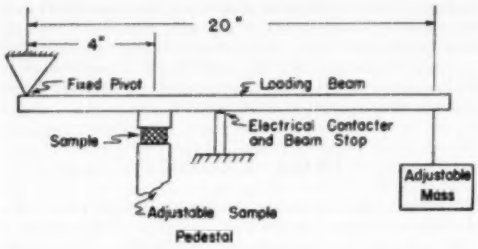

FIG. 5 SCHEMATIC DIAGRAM OF STRESS-RELAXATION TESTING EQUIPMENT

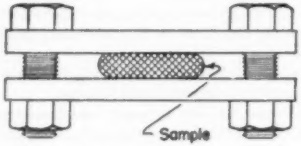

FIG. 6 STRESS-RELAXATION TESTING JIG

A simple tester was designed to provide a method of compressing a sample a predetermined per cent of its original height, and measuring by an adjustable dead-weight loading, the minimum stress necessary to maintain this deflection as a function of time. As this property of rubber and rubberlike materials is temperature-dependent, the machine was enclosed in a temperature-controlled air oven. The maximum load which it is possible to apply to the test specimen is 1000 lb. To increase the number of tests which could be run simultaneously, special jigs were made. These jigs made it possible to remove the sample and jig from the tester, while the desired compression was maintained on the sample, and to place the assembly into an oven at whatever temperature desired. Other tests could also be made and the stress checked periodically by placing the jig and sample into the tester and determining the stress to maintain the original deflection. These jigs were used exclusively for long-time tests.

The test sample used in the major portion of this work was the ASTM compression set sample, 0.500 in. in height and 1.129 in. in diam, giving an area of 1 sq in. These samples were diecut from 6 × 10-in. sheets of the compounded cured rubber.

Seven natural and synthetic rubber compounds were used in this work: (1) Natural, (2) Natural + T.M.T.D., (3) GR-S, (4) Neoprene GN, (5) Hycar OR-15, (6) Hycar OR-15 + T.M.T.D., (7) GR-I.

The test procedure consists of conditioning two samples at the same time until equilibrium temperature is attained and the free heights of the samples are measured. The sample pedestal is adjusted to give the correct compression and the first sample is loaded in increments until the predetermined compression is secured. This operation required about 30 to 40 sec. This sample is discarded and the sample pedestal is reset if necessary. The stress found necessary to produce the desired deflection is then imposed on the second sample, time being measured in seconds from the moment compression starts. Thirty-six seconds or 0.01 hr is usually the shortest time in which it is possible to determine accurately the compression stress so it is usually spoken of as the "zero" time. Successive readings are

in approximately a geometric progression from 0.01 hr as the curve of stress relaxation is approximately a straight line when plotted against logarithmic time.

Several factors are involved in compression testing of rubber. In the usual test the rubber sample, usually a cylinder, is compressed between metal plates which may be smooth machine finished with a high polish, or have grooves, serrations, or other surface roughness to minimize slippage. In this work it seemed desirable to determine experimentally whether the sample geometry had any effect on compression stress relaxation. It was concluded that stress relaxation is independent of sample shape or size within reasonable limits. However, it was found that the initial stress varied greatly with change in geometry of the test piece.

Lubricated surfaces, which most nearly approach compression only in that the sides of the sample do not bulge, give lower values of stress for comparable deformation as would be expected.

No significant trend in the data resulting from slippage was observed. Bonded, unbonded, and lubricated samples were tested.

Tests made in the laboratory showed no effect of degree of deformation. A maximum deviation from the mean of about 2 per cent was found in one case.

In Fig. 7, which shows the effect of polymer, it is seen that the materials arrange themselves in various orders of superiority depending on the time at which the curves are observed. The GR-S stock is the only stock giving essentially a straight line for values on this plot. The differences between compounds observed early in the test period are influenced largely by the elasticity of the rubber while the departure of the curves from a straight line seems to indicate the effect of oxidation on the rubber. Fig. 8 shows that by the use of a particular nonsulphur cure it is possible to improve the compression stress relaxation of both Hycar OR-15 and natural rubber.

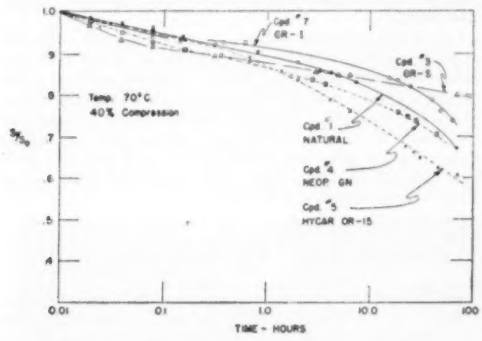

FIG. 7 EFFECT OF TYPE-POLYMER ON TEST RESULTS

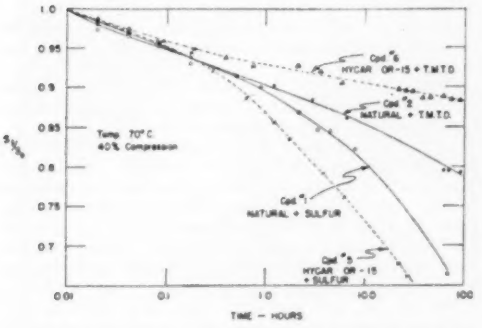

FIG. 8 EFFECT OF TYPE OF CURE ON STRESS RELAXATION

Several effects are superimposed in the data secured as a function of temperature. The one having the greatest effect on the results in this investigation is the "highly elastic" component of reversible deformation in rubberlike materials associated with the Brownian or heat motion. During deformation, the highly elastic component of deformation is associated with a rearrangement of the structural elements and lags behind the change in external force by an amount dependent on the mobility of heat motion of the elements. The heat motion in rubber is critically dependent on temperature; at low temperature it is small and rearrangement of the particles proceeds slowly so high elasticity is suppressed.

The relaxation or orientation in the material becomes larger with low temperatures and shorter with high temperatures.

Table 1 summarizes the data on the effect of temperature on the stress relaxation of the seven compounds tested. From this table it is readily seen that a compound which gives good results at room temperature does not necessarily retain this property at high temperature or low temperature when compared to another rubber compound. For example, Compounds 1 and 2, or 2 and 7, show this markedly.

TABLE 1 SUMMARY OF STRESS-RELAXATION DATA

Compound	Time in hours $S = P/S_0$ to reach 0.7 at temperatures of 25 C	24 C	45 C	70 C	100 C	130 C
1	21	4,000	700	50	2.7	0.16
2	1.2	700	700	220	185	13.
3	0.1	100	700	300	100	3.0
4	67	83	83	45	3.1	0.3
5		1,200	130	16	1.0	0.25
6		50,000*	15,000*	2,100	130	27.0
7	0.02	3,500	400	80	5.2	.165

* These figures are extrapolated.

The full text, with illustrations, of this paper, "Stress Relaxation of Some Rubber and Synthetic Rubber Vulcanizates in Compression," appears in the February, 1950, issue of *India Rubber World*.

Plastic-Deformation Studies

CHANGES in the orientation of the crystals, or grains, that make up the commercial metals are known to play an important part in the plastic-deformation process. However, attempts to study grain orientation by the usual x-ray diffraction methods have been rather unsuccessful where only minute areas are involved. An obvious difficulty, for example, has been the identification of the area from which the diffraction pattern was obtained. Recently, the National Bureau of Standards, in the course of a study of plastically deformed monel metal, developed a technique which uses polarized light to make visible differences in orientation that result from the deformation of a fully annealed specimen. Though use of the technique has thus far been confined to monel, the method is expected to find application in studies of plastic deformation in other metals.

When monel is polished and treated with most etchants, it is optically isotropic, reflecting polarized light equally in all directions. However, when specimens were given a light etch (about four seconds) with the monel contrast etch (an aqueous solution of chromic and nitric acids in ammonium chloride), the

surface of the metal became optically active. Under these conditions polarized light can be used to detect differences in grain orientation.

Monel that had been annealed so as to give uniform point-to-point orientation within individual grains was viewed microscopically under polarized light with polarizing elements in the incident and reflected beams crossed. The intensity of the reflected light was uniform over each grain. However, when the annealed monel was deformed before being sectioned and polished, the intensity of the reflected light was no longer uniform over the individual grains. It was thus possible to study visually those regions which had undergone changes in orientation.

Tensile specimens that had been given different amounts of plastic extension were sectioned and polished and used to study the effect of increasing plastic deformation on the changes in orientation within individual crystals. From the irregularity of these changes, it was evident that directions of flow varied within small areas and that the deformation in individual grains was by no means uniform or regular. Furthermore, the deformation was confined neither to the areas near the grain boundaries nor to the center of the grains but depended upon the orientation of adjacent crystals and the direction of the stresses they imposed.

Thin straight parallel lines known as "slip lines" are usually visible on polished and etched surfaces of annealed metals after slight deformation. Sometimes these lines are curved on specimens that have been deformed previously. There has been some question as to the interpretation of this curvature. Some investigators have suggested that a group of such curved lines represents a set of crystallographic planes which are bent; others contend that the curves are the traces of several sets of parallel crystallographic planes which remain straight but combine to give the effect of curved lines. Use of polarized light at the Bureau to show differences in orientation along the length of a line indicated that the slip lines were traces of crystallographic planes that had been bent prior to the formation of the slip lines. Some of the differences in orientation observed in individual grains, which were more pronounced after severe plastic deformation, may therefore be interpreted as bending of the crystal lattice. This bending of the crystals during plastic deformation leads to the development of deformation bands. As deformation proceeded, these bands behaved as individual crystals and thus could be considered as fragments of the original crystal.

It was found that the total intensity of the combined reflections from many grains varied as the specimen was rotated with respect to the plane of polarization. Since this integrated intensity increased with greater deformation, it appeared that polarized light might be used to detect preferred orientation resulting from such shaping processes as drawing, rolling, and stamping. Preliminary results indicate that the Bureau's method is more sensitive than x-ray-diffraction methods for this purpose. Recently it has been found that other cubic metals, such as copper, aluminum, nickel, and alpha iron, can be made optically active. Thus this new application of polarized light can be used in the study of a number of commercial metals.

Thallium

THALLIUM, a rare element about as heavy as lead, performed an important World War II job in transmitting secret intelligence, and now is being turned to a number of new peacetime industrial uses, according to a Bureau of Mines publication released by the Department of the Interior. Before the war, this bluish-white metal was known principally for its use in refractive glass and in rodent poison and insecticide solutions.

Greater security in sending military information by light-wave communication was made possible by the development of infrared optical instruments with lenses made of mixed thallium-bromide-iodide crystals, the Bureau report disclosed. This method of "dark-signaling" was effective where there was danger of radio messages being intercepted. Photosensitive cells using thallium compounds also proved highly valuable in war communications systems.

Discovered by a German scientist about 1861, thallium is widely distributed in nature, but only in the combined state. It occurs in such minute quantities that its recovery is commercially feasible only as a by-product of other industries. In the United States, there has recently been only one producer and the metal is recovered as a by-product of zinc-cadmium operations.

The principal thallium-bearing minerals recognized so far are crookesite, lorandite, hutchinisonite, and urbanite. Many common minerals contain traces of the metal and it occurs in small quantities associated with other metallic sulphides in iron, copper, lead, zinc, and manganese ores. In addition to natural sources, industrial wastes and residues from metallurgical and chemical processes yield thallium in a more concentrated form.

Despite the abundance of thallium in minerals, the Bureau report points out that additional research is needed to develop a practicable process for extracting the metal as a primary product. Methods for concentrating thallium by standard ore dressing, as well as by leaching and volatilizing, are being investigated by metallurgists at the Bureau's Salt Lake City, Utah, laboratories.

Few, if any, industrial uses are known for metallic thallium, its greatest consumption being in compounds. It is also used in some alloys, such as lead and silver. Thallium sulphate is the principal ingredient of an effective tasteless and odorless rodent poison and insecticide. Its use in medicine is limited because its compounds are toxic. Various other compounds are used in making optical glass and artificial gems, and processes have been patented for using them as an antiknock agent and in manufacturing signals and rockets.

Electrolytic-Tin-Plating Line

A NEW electrolytic-tin-plating line, said to be the largest and fastest line of its type in the industry, has been placed in operation recently by Weirton Steel Company, Weirton, W. Va. The production capacity of the new line, which coats steel strip at speeds from 2000 to 2500 fpm, makes the Weirton plant the world's largest independent tin mill.

The new electrolytic line gives Weirton a total of four such lines, three producing tin plate and one engaged in coating steel strip with zinc.

The rated capacity of the new electrolytic line is 5,000,000 base boxes per year, bringing the company's tin-mill production capacity to 15,000,000 base boxes annually.

A "base box" is equivalent to 112 sheets of plate 14 in. × 20 in. The base weight of a base box establishes the thickness. Plate is rolled to base weight and therefore the calculated thickness expressed in ten thousandths of an inch is only an approximate equivalent. Although electroplated tin plate may be purchased in coils, the majority of tin-mill products are sold in sheet form. The maximum sheet size is about 35 in. wide and 50 in. long. The smallest size tinned is about 10 in. × 19 in.

The new line, with an electrical capacity of 12,000 kw, produces as much tin plate on a single line as could be obtained from 25 of the most modern automatic-fed tin pots. Weirton's lines

have high-frequency induction heating for the reflow brightening of the tin coating with a total installed capacity of 9000 kw.

Basically, the electrolytic tinning process is the same as the making of electrotypes from engravings, a process common to newspaper and magazine publishing. The difference is that in the making of electrotypes, metal is transferred from an anode to a stationary object, whereas in the case of the electrolytic process, the metal is transferred to the continuously moving strip.

Aluminum Plants

Aluminum Reduction Plant

THE new Point Comfort aluminum reduction plant recently placed in partial operation by the Aluminum Company of America near Port Lavaca, Texas, is unusual since it employs radial internal-combustion engines burning natural gas to generate electric power. It takes about 10 kwhr of electricity to produce one pound of the metal.

Natural gas is delivered to the works at a pressure of from 400 to 500 psi. This pressure is reduced in two stages to 60 lb. Two 8-in. gas lines connect each of the three powerhouses with the pressure-reducing station. A regulator at each engine further reduces the intake pressure, and in actual operation, gas enters the engine at a pressure of about 6 lb.

Each engine consumes gas at a rate of 13,000 cu ft per hr under load. Normally the plant will use more than 30,000,000 cu ft of gas per day.

Nominal generating capacity of the power plant is 120,000 kw. Under normal operating conditions, the total output of the plant will be approximately 2,750,000 kwhr per day.

One hundred twenty engine-generator units convert the gas into electrical energy. Forty units are housed in each of three engine rooms, one for each pot line.

The engines are a two-cycle radial type built by Nordberg Manufacturing Company, Milwaukee, Wis. With slight modifications, the engine can be adapted to gas, Diesel fuel, or dual-fuel operation.

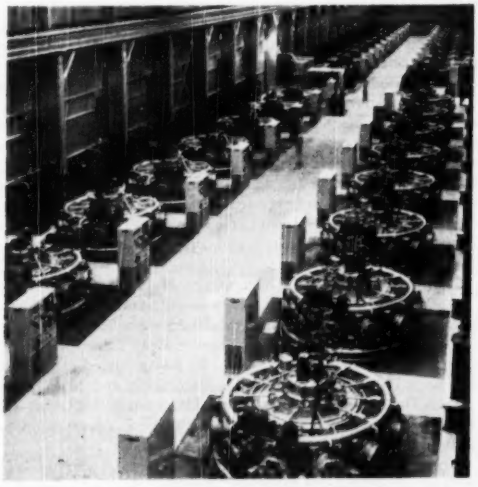

FIG. 9 ONE OF THREE RADIAL-ENGINE ROOMS, EACH CONTAINING 40 ENGINES AT POINT COMFORT WORKS

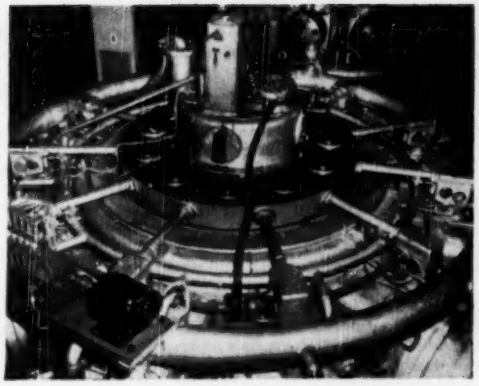

FIG. 10 CLOSE-UP OF RADIAL ENGINE SHOWING GOVERNOR, DISTRIBUTOR, LUBRICATOR, AND GAS VALVES

The 11-cylinder engine has a 14-in. bore and a 16-in. stroke. At Point Comfort, the engines are normally operated at 360 rpm, producing 1600 hp. They operate at a thermal efficiency of about 29 to 30 per cent.

The crankshaft is set vertically with the crank at the top. The cylinders are bolted radially to a cast frame, having a central hub that carries both the lower crankshaft main bearing bushing and also the thrust bearing which supports the load of the crankshaft. The heavy bolted cover contains the upper crankshaft main bearing bushing. The governor, fuel pumps, mechanisms for gas operation, and controls are located on this cover. Circular manifolds for scavenging and exhaust are located in the lower level of the engine room. Intake and exhaust are timed by the pistons uncovering ports in the cylinder walls, and no valves are required.

Balanced operation is accomplished by use of a master gear, a stationary gear bolted to the cover, two pinions, and rotating counterweights. The 11 connecting rods are attached to the master gear by means of knuckle pins mounted in bronze-bushed bearings. The master gear gyrates instead of rotating. There is no master connecting rod, commonly associated with radial-type engines.

Two systems of lubrication are used. Motor-driven multi-feed lubricators deliver oil to each cylinder for piston lubrication. A circulating pressure system provides oil for all other parts requiring lubrication and also for piston cooling.

When set up for gas burning, the engine operates on reduced compression, with spark ignition. Natural gas is admitted by cage-mounted gas valves. The valves are operated by a cam on the crankshaft and are so located that gas is admitted into the path of incoming scavenging air. This assures thorough mixing and efficient use of the fuel. A valve inserted in the gas line and controlled by a governor varies the amount of gas delivered to the cylinders according to the load on the engine.

The electric generators are located in the lower level of the powerhouses and are joined to the engines by direct coupling. Each engine-generator, with auxiliaries, operates independently.

Each generator produces 1000 kw (dc) at 667 volts and 125 kva (a-c) at 425 volts and 24 cycles. The a-c power is used for driving the engine auxiliaries. This eliminates the need for a common auxiliary power system and possibility of a total station interruption.

The generator is used as a motor in starting the radial engine.

The Point Comfort works will have the capacity to produce about 114,000,000 lb of aluminum per year. Reduction of aluminum oxide to aluminum will be done electrolytically.

Aluminum Rolling Mill

Aluminum Company of America also announced the opening of its new sheet and plate-rolling mill, at Davenport, Iowa. This mill, it is reported, produces aluminum sheet in much larger coils than ever before continuously strip-rolled in industry. It can make high-quality aluminum plate in larger sizes than any other aluminum plate mill in existence.

Probably the most spectacular of the integrated plant operations is hot-rolling in the five-stand continuous sheet mill. Housed in a building more than 1700 ft long, the precision machines of this mill transform a relatively stubby ingot into a coiled strip well over 1000 ft long and less than $\frac{1}{8}$ in. thick.

Blast-Furnace Restoration

RESTORATION of one of the earliest industrial landmarks in America, the first ironworks and blast furnace to be operated in the New World, is under way at Saugus, Mass. It is expected to be completed and opened to the public late in 1951, according to the magazine *Steelways*, published by the American Iron and Steel Institute.

The iron works, which dates from 1644, is being restored as a permanent tribute to the iron workers of colonial days and to their successors, who have increased daily production of the 1640's, one ton of bar iron, to an industry producing more than a quarter-million tons of steel per day. This unique industrial shrine is expected to attract half a million tourists annually.

Until recently the site at Saugus was a patch of ground overgrown with weeds and brambles, on the banks of the little Saugus River, 10 miles from Boston, the *Steelways* article states.

Following clues based on fragmentary records, an archeological crew already has brought to the surface more than two tons of relics of the iron works. They include iron rings, nails, tools, kitchen utensils, and many other objects. A mine detector such as those used in World War II is one means by which the artifacts are being located.

The First Iron Works Association, which was formed in 1943, is carrying on this work of restoration of the blast furnaces of colonial days.

Jet Airline Service

AVIATION authorities throughout the world are preparing to fit British civil jet airliners into air-traffic routes much earlier than they had planned, according to a recent Society of British Aircraft Constructors, Ltd., newsletter. This is because operational tests on the airplanes have by far exceeded expectations. The New Jersey Conference of I.A.T.A., formed by the 70 principal airlines of the world, has been concentrating on practical plans for the new and revolutionary gas-turbine-engine airliners. In Britain a working party has been set up by the Ministry of Civil Aviation. The Ministry is rapidly revising internal air-traffic controls to operate the Comet when it goes into service next year. On the world's airline routes the piston engine will soon be a thing of the past, the newsletter states.

City-to-city flights have shown that the gas-turbine airliners can be handled by present-day traffic-control methods. The Avro Canada Jetliner has flown into Idlewild Airport, New York, N. Y.; the Vickers Viscount and de Havilland Comet have operated from the principal cities of Europe. Sir Miles Thomas and Sir Frank Whittle have made a special visit across the world to plan the Comet's projected service on Empire routes next year. As a result, airports in the Middle East, India, and Australia will be ready to receive the Comet.

It is reported that existing runways have proved adequate for jet airliners. Some experts even believe that jet transports will tend to need less runway than comparable piston-engined aircraft. The wing loading of the Comet, which is lower than many piston-engined aircraft of the same size, has proved the answer to the high landing speeds of propless aircraft. Both the Jetliner and the Comet have given visible proof of their ability to make short take-off and landing runs. The Comet can use standard runways even in rarified air and tropical conditions. At Nairobi, which is 5270 ft above sea level, it operated from normal runways on the airfield at Eastleigh.

Maintenance on the gas-turbine engine has proved remarkably simple. On its tour of European capitals, the engine cowlings of the turboprop Rolls-Royce engine of the Viscount were removed only for inspection by foreign airline officials. The Ghost turbojet engines of the Comet needed only three man-hours' overhaul time during two weeks' intensive flying in Africa. In spite of temperatures at Khartoum which brought the Comet's metal skin up to 160 F, the engines needed no modification on return to this country.

Atom Chart

INFORMATION on more than 1000 kinds of atoms is given on a new chart being distributed free to scientists in industrial laboratories, colleges, and universities by the General Electric Research Laboratory.

Printed in checkerboard fashion on heavy paper 26 × 50 in., each of the 96 chemical elements which were known at the beginning of the year is given a horizontal line, in which a square is devoted to each kind of atom, or "isotope," of that element.

The shading of each square indicates whether it is a stable form that occurs in nature, a radioactive form that occurs naturally, or one artificially radioactive produced in atom-smashing experiments. Its position on the chart shows the composition of its atomic nucleus, with the number of protons and neutrons. Among data given for each isotope are the proportion that it normally constitutes of the natural element; if radioactive, the speed at which it decays and the radiations emitted; whether it appears as a product of the fission of uranium 235; and an important technical datum known as the "thermal neutron absorption or activation cross section." For radioactive isotopes the speed of decay and the radiations emitted are given.

It is known as the "Chart of the Nuclides." The word "nuclide" is a general term, given to different kinds of atomic nuclei whether of the same or of different elements.

The first edition of the chart (then called "Chart of the Isotopes") was issued in May, 1948. It was prepared in the G-E Research Laboratory by Drs. G. Friedlander and M. L. Perlman. The revision was made by Dr. John R. Stehn of the Knolls Atomic Power Laboratory, which G. E. operates for the Atomic Energy Commission.

Copies of the chart and an accompanying explanatory booklet will be mailed free to interested persons. Requests should be addressed to Dept. 6-221, General Electric Company, Schenectady 5, N. Y.

ASME TECHNICAL DIGEST

Substance in Brief of Papers Presented at ASME Meetings

Dust Collection and Control

The Engineer and Management Look at the Value of Dust Control, by T. J. Barry, Mem. ASME, Consultant, Industrial Dust Control, Pittsburgh, Pa. 1950 ASME Process Industries Division Conference paper No. **50—PRI-9** (mimeographed).

A DUSTY atmosphere in a plant working area is not only a nuisance, it produces a health hazard, an explosion hazard, it affects the product, it causes excessive wear on the equipment, and causes the workers to do anything but their best work.

Any dust that is combustible can explode if the proper dust loading and a spark get together in the presence of sufficient oxygen. The 1950 copy of the National Fire Protection Association Codes, Volume II, contains 37 pages of recorded dust explosions involving many types of dust. The Medical Associations, the Industrial Hygiene Foundation, and others have compiled a vast fund of information on the effects of workers inhaling many types of dust.

The dust-control engineer has at his disposal a number of different types of dust collectors, each of which has its place in the scheme of things and each of which has definite limitations.

If he makes a thorough analysis of the problem he will automatically evaluate all of the phases of the job. In doing so, the results to be obtained will usually indicate what type of equipment is best suited for the particular problem.

The dust-control job, however, is not just the selection of the proper type of collector—it includes the design of the hoods where required, the duct system, the selection of the type of fan, the disposal of the collected material, making provisions for maintenance, and the safety precautions for the entire system.

Bag-Type Dust-Collector Problems, by Herbert I. Miller, St. Joseph Lead Company, Josephtown, Pa. 1950 ASME Process Industries Division Conference paper No. **50—PRI-20** (mimeographed).

TEMPERATURE, moisture, and chemical action have been the three big limiting factors in the employment of bag filters in lead and zinc milling and smelting.

Cotton and wool bag life are related somewhat inversely to high temperatures, even though the charring point is never approached. Failure is due to cracking along lines of flexing, usually above the thimble at the foot of the bag; and the appearance is that which would be expected in a more brittle substance. When new bottoms are sewn onto the old bags, the fabric tends to pull apart at the seam. Dust-collector-manufacturer representatives state that wool fabric will withstand 250 F for a short time but rapidly becomes inelastic; at temperatures below 150 F the wool that is not subject to chemical action may last indefinitely. Most smelter gases are generated at quite high temperatures and may be at 1000 F at the point of pickup. Even certain dust-collection points in the handling of hot materials may contribute 500 F gases. These gases must be cooled to a point where dust-collection equipment will handle them. However, cooling below the dew point must be avoided.

Condensation in bag collectors is to be avoided because damp or wet dust will plug bags, will not shake off while still damp, and may not shake off after drying. Moisture also greatly accelerates corrosive action from acid gases, or dusts; and these may act on both metal and fabric. Gases entering the collector must be well above dew point and in some cases the collector insulated as completely and carefully as required to keep above the dew point.

Abrasion is another factor to consider. Coke dust, for instance, is very abrasive and is suspected of contributing to failure by working into the fabric and wearing along crease lines while the bag is being shaken.

In regard to shaking, vigorous shaking without undue stretching of the fabric is desirable. Some older-style baghouses employ a gentle side-to-side motion in order to protect the bags. The bag cleaning is poor; but, by using enough bag surface to filter at a rate of one linear ft per min, they do a good air-cleaning job. The dust load may be 1 to 3 grains per cu ft. Such an installation has a high initial cost per cfm treated, and the trend with new installations is to increase the

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rate of flow through the filter and shake more often and more vigorously.

Unsolved Dust-Collection Problems in the Process Industries and the Difficulties Attending Their Solution, by Philip F. Best, The Thermix Corporation, Greenwich, Conn. 1950 ASME Process Industries Conference paper No. **50—PRI-8** (mimeographed).

AVAILABLE for the solution of industrial dust problems are the following basic methods of collection: (1) Mechanical or centrifugal, (2) filters, such as bag collectors, (3) electrostatic precipitators, (4) sonic agglomeration, and (5) washers.

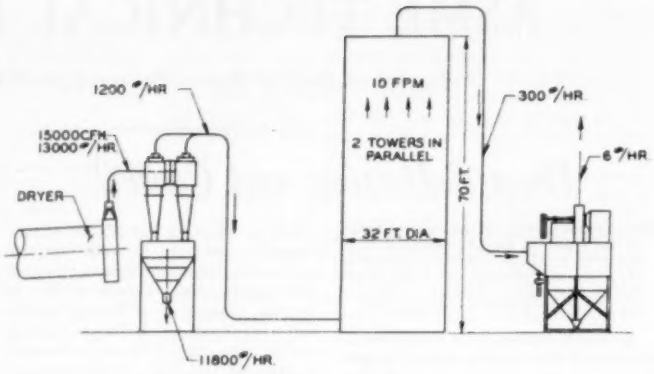
Two notable contributions have been made to the solution of dust-collection problems by the author's company. One involves the cleaning of natural gas in all phases from the time it leaves the gas well until it is distributed into the home. Many of these units are now in operation, and inasmuch as they accomplish this cleaning of the gas in a dry manner, they eliminate many of the difficulties previously experienced with gas scrubbers which operate by wetting the dust particles with oil and collecting them in a sludge.

The other application involves the cleaning of intake air to internal-combustion engines and compressors. Maintenance has been successfully eliminated by an impingement-type filter, and efficiencies higher than those obtainable by other methods have been integrated.

What Can Be Done to Reduce Escaping Solids From Stacks Exhausting High-Temperature Gases From Furnaces, Kilns, Roasters, Driers, and Similar Process Equipment, by John M. Kane, American Air Filter Company, Inc., Louisville, Ky. 1950 ASME Process Industries Division Conference paper No. **50—PRI-11** (mimeographed).

PARTICLE SIZE of solids in stack gases, particularly from kilns, furnaces, roasters, and like equipment where melting or chemical reaction such as calcining takes place, is very small with high percentages of the material by weight in the low or submicron range. In rotating kilns or driers, the stack gases flowing through the cascading material air convey high concentrations of fine solid particles from the process and up the discharge stacks.

The dry-type centrifugal will seldom be selected except as a primary separator to remove the bulk of a heavy loading in a gas stream. Also fabric-type arresters will have little application to cleaning problems of this type. The other basic types of equipment left for consideration are the high-voltage electric precipitator and the wet-type dust-collector designs.



COLLECTION REQUIRED BY LIMESTOANE DRIER

Wet-type dust-collection methods have proved to be the answer to many stack-gas cleaning problems. Collection efficiency is high on particles in the small micron size, and the high temperature and/or moisture-laden gases can be handled without difficulty. Shortcomings could be listed as troubles from corrosion where acid-forming gases or materials are involved, and the reduced collection efficiency on submicron particles encountered in metal fume collection problems and similar applications.

The collection required to satisfy public-nuisance complaints from neighbors in a plant area can be illustrated by a limestone drier problem. It drives home the importance of a high degree of solids removal when heavy concentrations are involved, and points out that primary collection even with 90 per cent removal in such cases will not alter discharge appearance or neighborhood complaints. The addition of the wet collector to remove practically all of the solids proved the needed answer to such a problem.

Cottrell Electrical-Precipitation Equipment in the Process Industries, by N. W. Sultzer, Mem. ASME, Research Corporation, New York, N. Y. 1950 ASME Process Industries Division Conference paper No. **50—PRI-15** (mimeographed).

THE Cottrell electrical-precipitation process is essentially an electrostatic method of removing suspended particles either solid or liquid from a gas. This is accomplished by subjecting the gases carrying the suspended particles to a high-voltage unidirectional electric discharge between two spaced sets of electrodes. One set of these electrodes is filamentary such as wires, rods, etc., and are known as the discharge electrodes, while the other set has extended surfaces such as plates and are designated as collecting electrodes. In industrial gas-cleaning problems the discharge electrodes usually are maintained at a negative polarity and the collecting electrodes positive.

The commercial equipment consists of two parts: (1) The electrical equipment for producing the high-voltage unidirectional current for use in the precipitator, and (2) the precipitator itself in which the gases are treated and the suspended particles removed.

The electrical equipment consists primarily of a switchboard with necessary meters and control equipment, a high-tension transformer for stepping up the plant power supply to approximately 35 to 75 kv; and a rectifier for converting the high-voltage alternating current to unidirectional current.

The precipitator in which the gases are treated consists of a shell in which are grouped the collecting and discharge electrodes. In pipe-type precipitators the collecting electrodes consist of pipes 6 to 12 in. in diam, grouped in a header plate and through which the gas flows. A discharge electrode is suspended axially in the center of each pipe. The plate-type precipitator is made up of a series of parallel plates encased in a shell, thereby forming ducts or gas passages through which the gas passes. A series of discharge electrodes are suspended in the ducts from an insulated framework. There are various forms, details, designs, and materials of construction of these two general classes of precipitators which are used dependent upon the analysis of the problem for which a precipitator is to be recommended.

Materials Handling

The Development of Belt-Conveyer Transportation, by R. W. Rausch, Link Belt Company, Chicago, Ill. 1950 ASME Process Industries Division Conference paper No. **50—PRI-18** (mimeographed).

THE assembly line, the mechanized foundry and the advance in foundry technique, precision production and interchangeability of parts, the mass production of ball and roller bearings, the rubber industry, the steel industry—all of these either had their beginning or at least were energized by the automobile industry. And the troughed belt conveyer is a contemporary of the automobile industry and owes much of its growth in usefulness and efficiency to that industry. The early rubber conveyer belts were crude and the rolls over which the belt traveled were unreliable and inefficient. The field of the belt conveyer was limited to the transfer of material, and up to about 1920 it continued to be considered only as a means of local transportation.

However, in 1920 the material and methods were available for the design and construction of a belt conveyer that could enter new fields—longer, and stronger, and bigger belts for increased tonnages, idlers with light, well-balanced, smooth-running steel rolls, requiring minimum horsepower and belt tensions to extend the conveyer over longer distances, built with the accuracy and the production methods of the automobile industry, built for low maintenance and reliability.

A large coal company initiated the belt conveyer into the transportation field in 1924. The belt conveyer entered competition to transport 1200 tons per hr of coal a distance of over four miles through a mountain to a barge-loading station.

In 1926, Denny Hill in Seattle was removed by means of a belt conveyer handling nearly 6 million yd of material at the rate of 900 yd per hr, running practically 24 hr per day, transporting this material over city streets without interference of traffic or damage to street paving, and delivering it to scows from which it was dumped into Puget Sound.

In the early 1930's belt conveyers were used to transport earth fill for building levees in Mississippi. Here field conveyers were used.

The dam-building program of the West was a fertile field for belt-conveyer transportation, and Fort Peck, Grand Coulee, Shasta, Anderson Ranch, and Bull Shoals Dam in Arkansas proved the success and the saving in cost of the belt-conveyer system of transportation.

The length of these conveyers depends, of course, on terrain conditions. At Shasta the conveyers varied in centers from 850 to 3400 ft; at Anderson Ranch from 500 to 1700 ft. At Grand Coulee the longest belt up to 1940 extended 4835 ft centers—handling 2000 tons per hr of stone at 450 fpm. At the Robena Mine of the H. C. Frick Coke Company, a 60-in. belt transports 2800 to 3000 tons per hr of coal at 600 fpm from the underground rotary mine car dumps to the screening, blending, and barge-loading station, a distance of 741 ft, and elevating the coal through 171 ft.

The highest-lift belt conveyer ever attempted, the strongest belt ever made, the largest horsepower motor and reducer ever hooked up to a belt-conveyer drive is now being erected at a Southern Illinois coal mine. It will convey 1200 tph of coal a horizontal distance of 3167 ft and elevate it 862 ft. The 42-in-wide belt will operate at 623 fpm under a maximum tension of 85,000 lb.

The Proposed Belt-Conveyer System in Ohio, Digest of Address by Noel R. Michell, Riverlake Belt Conveyor Lines, Inc., and The Akron, Canton & Youngstown Railroad Company, Akron, Ohio. 1950 ASME Process Industries Division Conference paper No. **50—PRI-17** (mimeographed).

THE development of Riverlake Belt Conveyor Lines, Inc., was started about two years ago when the A.C.&Y. Railroad proposed to extend the railroad 42 miles eastward to Youngstown. Surveys, however, indicated that: (1) there was not sufficient potential business in Youngstown and the contiguous territory to guarantee continuous and heavy tonnage, and (2) Youngstown as a steel center was not expanding.

It was found that Youngstown paid a manufacturing premium to get coal from the Ohio River and a premium on iron ore that came by rail from the Great Lakes ports, as compared with the Pittsburgh steel area that enjoys cheap water transportation, and Cleveland, Lorain, and Chicago where ore is delivered by water carriers. The steel people further pointed out that the recent increases in rail rates made Youngstown's position even more difficult.

Following preliminary studies, a two-way conveyer was proposed from East Liverpool in almost a straight line to Lorain, Ohio, a distance of 103 miles, with a 19-mile branch or spur from a point near Salem, Ohio, to serve Youngstown and the Mahoning Valley, and a 7-mile branch from a point near Parma, Ohio, to serve Cleveland. This overall 130-mile two-way belt conveyer could be built for approximately $210,000,000 and tariffs would be charged to permit amortizing this project over a 20-year period, still saving the consumers from 20 to 45 million dollars per annum.

Legislation was introduced in the Ohio legislature in February, 1949, to give conveyer-belt companies the status of a common carrier, subject to similar rules and regulations imposed on railroad, thereby the right of eminent domain to obtain the necessary right of way.

The opposition to the legislation was spear-headed by a special transportation committee of the Ohio railroads. They argued that a belt conveyer could not be a common carrier because it was not proposed to carry chickens, packaged goods, or whatever might be offered by the public. They introduced witnesses who said 15,055 railroad men would lose their jobs, that 70 trains would be discontinued, that millions of dollars would be lost to the railroads, that schools might have to close because of the loss of taxes. They painted a very black picture.

Many years ago the railroads were fighting the pipe-line operators as they are now opposing Riverlake Belt Conveyor Lines, Inc. Pipe lines, however, have brought new industry and wealth throughout the country and, as a result, railroads are hauling new tonnage that was not there until the new industry made this possible. Likewise, with the operation of the conveyer belt, new industries will come into being, existing plants will expand, more employment means more homes and durable goods, all of which means tonnage for the railroads. The conveyer belt will help other railroads just as it will help the A.C.&Y.

The building of this proposed conveyer is a large undertaking, costing an estimated $210,000,000. It will take nearly 33,000,000 man-hours, or 5400 men three years to construct the system. It will furnish tremendous employment to the manufacturers of the belts and other component parts. When in operation it will pay an estimated $7,000,000 a year in taxes—new taxes—and little or no state taxes paid by the railroads will be removed. It will furnish new jobs to operate the system. The power companies, which will supply the 250,000 hp to run the conveyer at full capacity, will have to build new substations, requiring new employees. The number of those new employees likewise will be expanded by river and lake-terminal operations, such as additional barge and river

dock employees, dock workers to man the lake-terminal operation, power-company employees to provide power for the terminals, in addition to the 250,000 hp already mentioned for the main line.

The proposed legislation to enable Riverlake Belt Conveyor Lines, Inc., or any other conveyer company to proceed will be reintroduced when the Ohio legislature convenes in 1951. With more time to study this matter and with the proper backing, it is hoped that the legislature will quickly approve the necessary enabling legislation.

Rotary Driers

Rotary Driers, by G. Gutzeit and J. Robert Spraul, General American Transportation Company, East Chicago, Ill. 1950 ASME Process Industries Division Conference paper No. **50—PRI-4** (mimeographed).

A ROTARY drier is essentially a machine comprising a horizontal cylinder revolving around its longitudinal axis, with a feeding and discharge device for the material to be dried, a method of supplying the necessary heat, and a means of removing the evaporated moisture.

The units differ primarily in the relative direction of flow of the heating medium and the material, these variations including parallel, countercurrent, indirect, and indirect-direct operation. The selection of drier type frequently is dictated by the material being dried, but if a choice is possible, the use of the proper drier can give improved capacity in any particular case.

Construction details of the important component parts of rotary driers are described and discussed, and solutions and suggestions are given concerning the problems of handling the material before and during drying in order to obtain a quality product. Pilot-plant data showing the importance of proper drier selection are compiled. Technical test results from commercial or pilot-plant units are shown for the drying of wood flour, bauxite ore, distillers, grains, alfalfa, and anthracite-coal flotation concentrates.

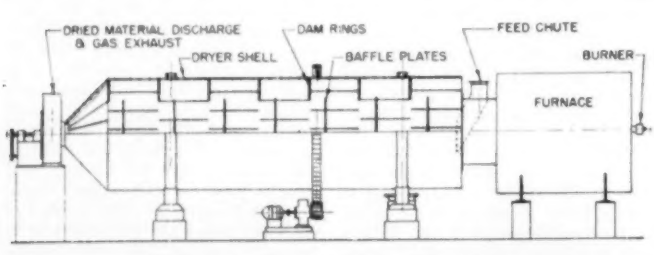
Spray Drying

Methods of Atomization in Spray Drying, by F. J. McEntee, Jr., Western Precipitation Corporation, Chicago, Ill. 1950 ASME Process Industries Division Conference Paper No. **50—PRI-5** (mimeographed).

SPRAY drying is becoming an increasingly important branch of the unit operation of drying. A spray drier may be classified as a direct type of drier in which heat transfer for drying is accomplished by direct contact between the solution or slurry to be dried and the hot drying gases. However, it differs from other types of direct dryers in that evaporation of liquid and resultant production of dried product is performed while the material being dried is suspended in the drying medium. The drying medium serves several purposes: (1) Heat transfer by convection between the hot gas and wet solution, (2) removal of vaporized liquid, and (3) as a conveying medium for removing all or part of the dried product from the drying chamber. Spray drying has been successfully applied to a wide variety of materials in the food, chemical, pharmaceutical, soap, and detergent fields.

In spray drying, the solids of the solution or slurry are converted to fine powder or to granular form by atomizing and dispersing the fluid into a mass of heated gas. A necessary condition for spray drying is that the material to be dried be in a fluid state. Successful operation of a spray-drying system requires solution of four basic operations, namely, (1) atomization of solution or slurry, (2) intimate mixing and dispersion of atomized spray and drying gas, (3) drying of liquid drops, and (4) effective removal of dried product from the gas stream.

A brief review of these four basic operations is presented for the benefit of those not familiar with spray-drying practice. Two theories of mechanism of atomization are discussed. Several types of atomizing devices in commercial use are described.



LONGITUDINAL SECTION OF A TYPE H ROTARY DRIER

Synthetic Fuels

The Role of Oxygen in the Production of Synthetic-Liquid Fuels From Coal, by H. R. Batchelder, R. F. Tenney, L. C. Skinner, R. G. Dressler, and L. L. Hirst, Office of Synthetic Liquid Fuels, Bureau of Mines, Louisiana, Mo. 1950 ASME Process Industries Division Conference paper No. **50—PRI-7** (mimeographed).

THE use of oxygen in the production of synthetic fuels is primarily a question of the gasification of coal to produce hydrogen for coal hydrogenation or carbon monoxide-hydrogen mixtures for Fischer-Tropsch synthesis.

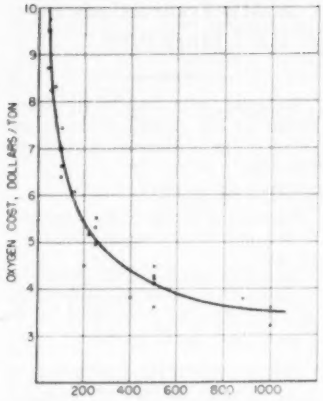
In a coal-gasification process, heat must be supplied to drive off and decompose the volatile components of the fuel, and to support the endothermic reaction between carbon and steam. This may be supplied internally by partial combustion of the fuel with oxygen, by intermittent combustion with air to store heat in the fuel bed, or by the application of external heat.

The use of oxygen in place of air or external heating of the gasification vessel may show one or more of the following five advantages: (1) Fuel economy, (2) increased capacity of equipment, (3) a wider range of possible fuels, (4) greater adaptability to pressure operation, and (5) a higher range of attainable temperatures.

Another possible advantage of the use of oxygen is the fact that higher temperatures are attainable, which may be desirable in order to destroy the tars and oils from coal, or to permit operation under slagging conditions.

As to the relation of oxygen cost to synthetic-fuel cost, it is well established that for the Fischer-Tropsch process about 690 lb of oxygen are needed to make 1 barrel of synthetic liquid fuel. This amount of oxygen at $5 per ton would amount to $1.72 per bbl, and at $3 per ton, amount to $1.03. On this basis then, each change of $1 per ton in oxygen will change the per barrel cost of synthetic fuel from this process by about 35 cents. For comparison, similar calculations made on coal would show that a change of $1 per ton in price would result in a change of about 40 cents per bbl.

In the coal-hydrogenation process, a relatively large part of the required hydrogen is to be recovered from the tail



EFFECT OF PLANT CAPACITY ON THE COST OF OXYGEN

gases by low-temperature separation and produced by reforming the product methane with steam. For this reason the oxygen requirement for coal gasification is only a fraction of that for the Fischer-Tropsch. It is estimated that about 90 lb of oxygen will be required to make 1 bbl of synthetic fuel by coal hydrogenation. At $5 per ton, the oxygen cost would amount to 22 cents per bbl of oil, and at $3 to about 14 cents. On this basis, each change of $1 per ton in oxygen cost will change the per barrel cost by about 4 cents.

Cemented Carbides

Cemented-Carbide Compositions for High-Temperature Service, by John C. Redmond, Kennametal, Inc., Latrobe, Pa. 1950 ASME Process Industries Division Conference paper No. **50—PRI-14** (mimeographed).

MATERIALS which show promise of greatly widening the scope of engineering design in the high-temperature field are the new cemented-carbide compositions. The refractory metal carbides as a class are the highest-melting materials known. In particular, the high melting point and low density of titanium carbide should be noted.

Cemented tungsten-carbide tool compositions are well established for machining and wear uses, and their ability to retain their strength and hardness at elevated temperatures is well known. However, it has been found that they oxidize rapidly at temperatures slightly above those encountered in cutting operations, and far below those required for gas turbines and the like. In addition, since the conventional compositions contain upward of 60 per cent tungsten carbide, their density is from 8 to 15, which is excessive for many applications. The cemented titanium-carbide compositions on the other hand, although being evolved from the tool compositions, looked more promising for high-temperature service.

Possible categories in which these materials have applications are as follows:

1 Applications requiring resistance to wear and oxidation such as metal spinning tools, hot shears, skid bars, etc.

2 Applications requiring high strength, resistance to oxidation, and thermal-shock resistance, up to 2200 F for extended periods.

3 Gas-turbine blades, both rotor and stator, operating up to 2000 F.

4 Applications requiring extended resistance to deformation and gas tightness at temperatures up to about 2800 F in neutral or reducing atmospheres.

5 Applications requiring short-time exposure to temperatures up to 4500 F in molten metals, high-velocity gas streams, and so on.

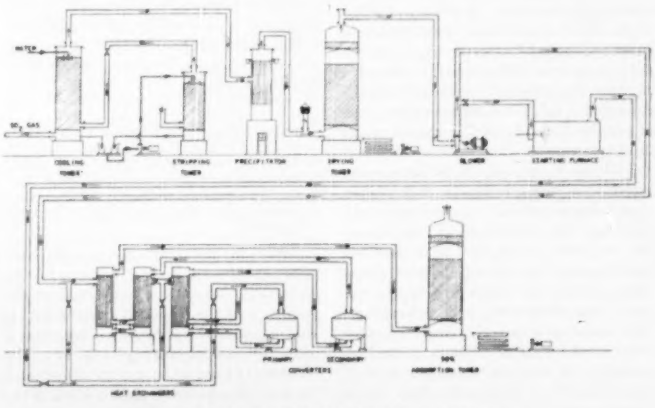
Waste-Acid Treatment

Recovery of Waste Iron Sulphate-Sulphuric Acid Solutions, by F. J. Bartholomew, Chemical Construction Corporation, New York, N. Y. 1950 ASME Process Industries Division Conference paper No. **50—PRI-3** (mimeographed).

A NEW process for the economical disposal of waste iron sulphate-sulphuric acid mixtures by recovering the acid value of both constituents is described. The process consists of concentrating the free acid, separating the crystallized iron sulphate by filtration, and processing the sulphate to fresh sulphuric acid.

The process need not necessarily be followed through to the point of producing fresh sulphuric acid from the iron sulphate. The complete plant requires a substantial investment and puts the purchaser in the sulphuric-acid manufacturing business. However, this is not as serious as it might appear at first thought. Sulphuric-acid plants have been added to metallurgical operations at great profit to the industry, and many large oil refineries are recovering sulphuric acid from refinery sludges and producing new acid from sludge and sulphur.

Steel mills operating at a lower rate of acid consumption might find the investment too heavy if the complete process were installed. In such cases only the concentrating and filtering procedure is recommended. This recovers about 85 per cent of the sulphuric acid delivered to the recovery plant and produces a sulphate that can be piled away on slag heaps or shipped as raw material to a nearby sulphuric-acid manufacturing plant. Recent studies indicated that if the sulphuric acid is concentrated and the filtered monohydrate converted into sulphuric acid, the investment required in the complete installation would pay for itself in 4 to 8 years depending on the cost of new acid delivered in the locality of the recovery plant, and other attending factors. If, on the other hand, only recovery of the free acid is desired and the client has a convenient means of disposing of the monohydrate, either to waste or



CONTACT SULPHURIC-ACID PLANT FLOW DIAGRAM

to some manufacturer of sulphuric acid, the investment would pay for itself in 6 to 12 months even if there is no sale value for the iron sulphate.

Management

Methods-Time Measurement, Digest of Address by Haylett B. Shaw, Methods Engineering Council, Pittsburgh, Pa. 1950 ASME Process Industries Division Conference paper No. **50—PRI-10** (mimeographed).

THE procedure known as methods-time measurement has been developed by Methods Engineering Council and thoroughly tested by application in 28 different factories. The procedure makes use of predetermined time standards for all motions employed to accomplish work. These were developed during several years of intensive research.

To use the procedure, the motions required to do a given job are determined by observation or analysis. Time values are assigned to each motion from data tables of predetermined times. The sum of the individual motion times gives the standard time for doing the job. Thus it is possible to establish production standards without using a stop watch.

Plastics

Strength-Variance Studies of Plastics, by W. J. Gailus, Mem. ASME, Steven Yurenka, and A. G. H. Dietz, Mem. ASME, Massachusetts Institute of Technology, Cambridge, Mass. 1949 ASME Fall Meeting paper No. **49—F-33** (in type; published in Trans. ASME, April, 1950, pp. 299–307).

PRELIMINARY work of the plastics research program at the Massachusetts Institute of Technology, sponsored by the Plastic Materials Manufacturers Association, is reported. A statistical study of the effect of pertinent variables likely to be encountered in gathering mechanical data from a representative system of plastics (polymethyl methacrylate) is described. Effect of manufacturer, rate of test, and nature of test specimen are reported.

This variance analysis of causes and interaction terms indicates that studies correlating structural characteristics of a material, whether chemical, metallurgical, etc., with its physical properties had best be done by testing samples whose homogeneity and degree of representation (reproducibility) of a material are understood and can, therefore, be taken into consideration. Further, the importance of considering interaction effects has been indicated. The latter, if not considered, can easily lead to false conclusions or effectively mask effects that may occur.

In the case of the plastic materials analyzed in this paper, it has been found that in order to eliminate as many interactions as possible, future testing should be carried out using material (for particular phases of the work) from a single manufacturer, with samples taken from panels of the same thickness, using a predetermined random sampling procedure for obtaining specimens, and using material which has been prepared by a carefully controlled technique.

Instruments

Theoretical Considerations on the Optimum Adjustment of Regulators, by P. Hazebroek and B. L. van der Waerden, N. V. de Bataafsche Petroleum Maatschappij, The Hague, Holland. 1949 ASME Industrial Instruments and Regulators Division—Instrument Society of America Conference paper No. **49—IIRD-1** (in type; published in Trans. ASME, April, 1950, page 309).

IN a companion paper, the authors propose some practical rules for the best possible adjustment of the parameters of automatic regulators with proportional-plus-integral action. This paper is concerned with the theoretical foundations of the method developed.

The Optimum Adjustment of Regulators, by P. Hazebroek and B. L. van der Waerden, N. V. de Bataafsche Petroleum Maatschappij, The Hague, Holland. 1949 ASME Industrial Instruments and Regulators Division—Instrument Society of America Conference paper No. **49—IIRD-2** (in type; published in Trans. ASME, April, 1950, page 317).

IN this paper a practical method is proposed for the adjustment of regulators in order to obtain the most satisfactory regulation of a process variable which should be kept at a constant value. The regulator is assumed to perform proportional and integral action, derivative action not being taken into consideration for the present.

Control Systems for Distillation Towers, by Cyrus Pyle, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. 1949 ASME Industrial Instruments and Regulators Division—Instrument Society of America Conference paper No. **49—IIRD-3** (mimeographed).

THIS paper describes, generally, distillation-tower control systems. An elementary analysis is made both of the behavior of the tower as a fractionating device and of the effect of various control systems on fractionating capacity. The variables placed under control are selected because they provide good indexes of the physical operation of the tower itself.

ASME Transactions for June, 1950

THE June, 1950, issue of the Transactions of the ASME, which is the *Journal of Applied Mechanics*, contains the following:

TECHNICAL PAPERS

Engineering Steels Under Combined Cyclic and Static Stresses, by H. J. Gough.

Some Experiments on the Interaction of Shock Waves With Boundary Layers on a Flat Plate, by F. W. Barry, A. H. Shapiro, and E. P. Neumann. (49—A-3)

Critical Load of Columns of Varying Cross Section, by W. T. Thomson. (49—A-1)

Stress Studies on Piping Expansion Bellows, by F. J. Feely, Jr., and W. M. Goryl. (49—APM-22)

Acceleration of the Instant Center, by W. J. Carter. (49—A-9)

Atomization of Liquids by Means of a Rotating Cup, by J. O. Hinze and H. Milborn. (49—SA-2)

An Approximate Solution for Incompressible Flow About an Ellipsoid Near a Plane Wall, by Phillip Eisenberg. (49—A-7)

Influence of the Dimensional Factors on Mode of Yielding and Fracture in Medium-Carbon Steel—II, by Julius Miklowitz. (49—APM-20)

Gaskets and Bolted Joints, by Irving Roberts. (49—A-2)

A Quantitative Comparison of Flow and Deformation Theories of Plasticity, by P. G. Hodge, Jr., and G. N. White, Jr. (49—A-5)

Free Periodic Motions of an Undamped Two-Degree-of-Freedom Oscillatory System With Nonlinear Unsymmetrical Elasticity, by W. W. Soroka. (49—SA-6)

Stresses and Deflections of Cylindrical Bodies in Contact With Application to Contact of Gears and of Locomotive Wheels, by H. Poritsky. (49—A-14)

On One-Term Approximations of Forced Nonharmonic Vibrations, by G. Schwesinger. (49—APM-17)

Longitudinal and Torsional Impact in a Uniform Bar With a Rigid Body at One End, by A. H. Burr. (49—A-6)

DISCUSSION

On Previously Published Papers by S. U. Benscoter; H. Majors, Jr., B. D. Mills, Jr., and C. W. MacGregor; D. C. Drucker; W. H. Hoppmann, 2nd; Joseph Marin; C. C. Miesse; and R. L. Sutherland.

BOOK REVIEWS

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Instrument Engineering

COMMENT BY PAUL T. GRAFF[1]

Control of final product by product inspection is ideal, as the authors state in this paper,[2] and is probably the best goal, but a good "systems engineer" will not impose a terrific requirement on a process controller when he can design his apparatus to make the quality desired on an economic basis with less elaborate control. Only recently a gas separation by rectification has been controlled by a very simple form of pressure control to assure less than 15 ppm of impurity in the gas. An analyzer controller proposed for use was unresponsive and insensitive; the only way to check the impurities in the product gas has been by mass spectrographic analysis of samples, and even that apparatus is insensitive to many constituents simultaneously.

Often, a product must be required to meet several specification inspection values. A single product character measurement may be made the controlling variable, then the other product qualities are controlled inferentially the same as though some process physical variable were controlled. Physical conditions do not form a group of dynamic relations different from product quality in many applications.

There seems to be a fundamental weakness of process control by product analysis and inspection. Automatic control must measure and function from deviation or error. A good systems engineer will select or create a threshold where he can regulate an operation effectively, and where control is simplest.

The systems engineer of this paper sounds like one of today's really fine project engineers who has been given a set of dynamic response data and instrumentation information equal to the design methods a project engineer uses in solving his process fluid-flow, heat-transfer, chemical-reaction, and equipment-design problems. Every phase of the design of a process plant benefits from the project engineer's studying and making some solution of the control problems at today's level of the art.

COMMENT BY J. G. KERLEY[3]

The authors of this paper are to be commended for their clarity of perception. Engineering theorists in the field of positional servomechanisms, they have recognized and emphasized two requirements that are very important in the construction and operation of processing plants, namely, the system concept of plant design, and the measurement of product purity, or quality, as a criterion for plant control.

The system concept of plant design is mandatory if the several factors which make up a chemical processing plant are to be considered. These factors include the process reaction itself, be it a chemical reaction, a physical separation, or other; the composition of charge stocks, catalysts, reactants, and by-products; the nature of the required reaction environment; the equipment for establishing the reaction environment; equipment for supplying and removing energy; and most important of all, the apparatus for maintaining the reaction environment, or altering it to meet the requirements for product yield and quality. The last item constitutes the instruments for measurement and control, and its position in this listing is significant. For many years it was the last item considered in plant design.

Fortunately, in the last few years its position has been moved further up the list. Designers realize that if a plant cannot be controlled properly there is little use in building it. Controllability is a prime requisite and, in at least some instances, is considered along with early studies of raw materials, processes, and environments. Indeed, a few plants have been built recently in which the method of control was established in conjunction with process and material studies. Experts were then called in to supply equipment having the characteristics required by the control method. In short, a modified form of the systems engineer suggested by the authors made use of the accumulated talents in his organization by group meetings in which all factors were considered and differences in opinion concerning details were reconciled. A combination line-and-staff organization was effected in this instance, and autonomy was subjected to the common good through compromise. Obviously, the systems engineer suggested by the authors would be the ideal "line" member of such a group. However, it must be recognized that, in process design, complete knowledge of the entire problem must be accumulated by years of experience.

The writer is in complete agreement with the idea that instruments for measurement and control of product quality would enable better process control. Control of environmental conditions is satisfactory only if the environment is suitable for the raw materials being processed. Unfortunately, the characteristics of the raw materials are seldom consistent, and conditions must be adjusted to fit the environment to the existing materials. At present this is largely done by spot samples and laboratory analysis—a time-consuming and wasteful procedure. The product-purity analyzer suggested is the obvious answer. It would adjust continuously the conditions of the environment to meet the requirements for optimum yield and purity.

This would of course complete the "control loop" and facilitate the use of system dynamics theory gained by intensive study in the field of servomechanisms. In general, we believe this knowledge can be applied very well in process control, and although our opinion is not substantiated by sufficient data, we think the authors are correct in advocating studies of the frequency functions of the process. Any instrument engineer, who has attempted to "tune" an instrument to a process by the two currently popular methods for optimum settings of automatic regulators, realizes that the more effective of the two is the one in which frequency and sustained cycling are taken into account. This is a crude example, we admit, but it points up the importance of system kinetics

[1] Engineer, Scarsdale, N. Y. Mem. ASME.

[2] "Instrument Engineering—Its Growth and Promise in Process-Control Problems," by G. S. Brown and D. P. Campbell, MECHANICAL ENGINEERING, vol. 72, February, 1950, pp. 124–127 and 136.

[3] Shell Oil Company, New York, N. Y.

and the frequency and phase relationships between instrument and process.

The authors' statement that additional data are needed on process kinetics is unquestionably true, and we agree that obtaining them will be expensive and hard to master. In most cases suitable measuring equipment is not available. Of equal importance, however, is the attitude of the plant operator whose duty it is to make profits with the process. In general we have found the operator willing to "tinker" with his process only if it is not performing its required tasks. Occasionally one finds an operator who is willing to experiment with his plant in the interest of better control, but this is rather rare. One of our colleagues recently informed us that when he is "playing with" an operating plant, the variable he watches most carefully is the operator's blood pressure.

This attitude is understandable when considered from the operator's point of view. His process is supposed to make money, and to him, all experimentation and research should be conducted on pilot plants. Even in pilot plants, however, we encounter difficulty, because pilot plants are seldom scale models of operating units, and differences in such factors as space velocities, surface/volume ratios, and the like, yield data difficult to interpret from the plant-scale point of view.

Obviously, the answer is to change the operator's point of view, and we heartily agree with the closing sentence of this paper, that it may take a decade or more to resolve the technical and human problems.

The authors have grasped the growth of control practices and the objectives of improved control quite effectively, and it would be interesting to watch the application of servomechanism techniques to the solution of process control problems. As a prisoner behind the barriers, as the authors express it, we are anxious to see these barricades broken down. We can think of no better method of attack than additional papers like this one.

COMMENT BY H. L. MASON[4]

The authors are to be commended for emphasizing afresh the equal importance of process dynamics and controller dynamics in determining the satisfactory performance of the over-all system or automatic-control loop. One reason, perhaps, why the subject is not stressed more frequently is that many chemical reactions and heat-exchanging processes are relatively "slow," as compared with their instrumentation, in responding to a disturbance. Another is that present-day commercial instruments, being supplied with a variety of controller response types and ranges of adjustment, can often be modified on the job. However, much of the existing theoretical literature on regulators and governors makes a point of the requirement of information on all the components of the loop. Only a start has been made on the publication of data for measuring instruments, final control elements, and typical controlled apparatus, and many more are needed.

The challenge to control the quality of the ultimate output is intriguing and may well be met in another decade or two. As a matter of history, automatic control of a process has usually come about in three stages, namely, (*a*) finding a way to measure a property, (*b*) making periodic laboratory checks on plant production, (*c*) comparing the measurement with a standard and using the deviation to alter the property.

Many an "application engineer" in the service department of an instrument manufacturer, and many an "instrument engineer," employed by more progressive chemical plants and oil refineries, will welcome the call to become a systems engineer. They know that they can do a better job of controlling variables if they are called in at an early stage of the design of processing equipment and would no doubt rise to the larger responsibility recommended by the authors.

Few of them, we conjecture, use the frequency-response techniques developed for the filters of communication engineering, and applied so successfully to electromechanical positioning devices, as outlined in this paper. They are more familiar with the response of an instrument or process to a step change. Fortunately, the Laplace transform is available to convert this result to an algebraic manipulation for the entire loop with results usually adequate, if sometimes deliberately approximate. For experimental work their exactness depends upon the accuracy with which measured or charted data can be expressed mathematically. True, this is the "transient" performance which the authors feel requires supplementing, but may it not be a desirable, even necessary, step in the educational development of individual or industry?

The broad term "control system" used by the authors seems much preferable to calling a regulator or a program controller by the name of servomechanism. Of these three devices, the first strives to follow a fixed command, the second a predetermined variation, the third an unpredictable variation. Each may be upset at more than one point in its loop by arbitrary disturbances. Any general technique of analysis found useful for one device can be applied for the others, and the student can and should be taught to handle all three with equal facility. To the writer, the clearest way of doing this for a linear system is to treat the effects of one disturbance at a time, whether it arises at an input shaft, a set-point knob, or a discharge valve. By this procedure we can set up transfer functions for whatever segments of the control loop are appropriate to the problem in hand and then combine them as needed.

COMMENT BY C. W. MILLER[5]

The authors are calling for a synthesis of recent advances in separated fields so that more complete and effective automatic control may result in better products with greater economy. This synthesis is ready to be accomplished—all the ingredients are at hand. It is only necessary to break down the now antiquated barriers which separate the technical minds of the various closed-loop fields and the technical minds behind the processes to be controlled. Then administrative minds must be awakened to a more modern organizational structure.

The authors make a clear point in that problems of control must be faced early in the paper work of a new process or plant. This will be even a deeper necessity as more-involved and inclusive control systems are developed, as they surely will be. The chemist and the engineer must contribute data to, and be influenced by, a systems engineer, responsible for the integration of the portions of the process and instruments into a well-controlled and economical production unit.

To be effective, as the authors state, the systems engineer needs to know all the factors affecting the frequency response of the process. Definitely, he must be given a voice in the design where the design will affect control. He must know completely the frequency and accuracy characteristics of existing control equipment. This may mean he makes or supervises appropriate measurements, for often such complete characteristics are not known, at least at the present time, by the control-equipment manufacturer.

The systems engineer should also have as complete specifications as possible covering the final product, and

[4] Research Professor, Mechanical Engineering, Iowa State College, Ames, Iowa. Mem. ASME.

[5] Perkin-Elmer Corporation, Glenbrook, Conn.

know how every variable in the process affects the final product. He also must understand the nature and magnitude of load variation and extraneous data which may enter the control loop, for such will influence his final choice of controller characteristic.

It should be realized that once the position of systems engineer is created with its possibility of broad outlook and knowledge, then further strides will be made in new control techniques, perhaps involving the wealth of knowledge available in the computer field.

It must be admitted that the systems engineer would have a difficult assignment, and probably there are too few people today with proper training. It is also true that much education of both process people and control-equipment manufacturers is needed before a systems engineer would not find his path very stony indeed. However, the pressure of new knowledge and the growing awareness of the as yet unrealized possibilities of control will force the birth of a coordinating position such as that of a systems engineer.

COMMENT BY A. J. YOUNG[6]

This paper recalls to the writer very clearly a discussion with the authors, which took place as long ago as 1946, on the general problems presented by automatic process control. The writer is glad to see that the authors also intend to follow up the lines of approach which were then agreed would lead most quickly to a fuller use by industry of the potential powers of automatic control. The general intention expressed in the paper of presenting the problems and their solution in a manner which can be understood readily by the process-instrument engineer is exactly the intention which lies behind the work carried out by the writer's company on this subject. Indeed the paper emphasizes the necessity of this approach just in time to prepare the way for a paper which it is hoped will be published shortly in England to describe this work.

The authors will have seen already the reports on progress in this field which have been sent to a few people in America who are known to be deeply interested and they will therefore be able to predict the treatment employed in the forthcoming paper. For those who have not seen these reports, it may be said that they show how the analysis of the frequency response of the process can be used to match to it a suitable controller. Starting with the same basic intention as the authors, effort has been concentrated on the use of frequency-response analysis in determining the characteristics of plants and controllers and for matching the one to the other. At a very early stage it was found to be desirable in the interests of clarity to treat the plant (which has been taken to include the detecting and measuring units) and the controlling unit separately. In order to obtain the required frequency-response data from existing plants, a pneumatic analyzer capable of producing these data has been built. Its success in use has been very promising. This analyzer does, in fact, meet the requirements specified in the paper in that the data it provides have fundamental significance, can easily be used to select the optimum modes of control and process controller settings, and are easy and inexpensive to obtain while the plant is running normally.

The results of the practical experience of frequency-response analysis on the plant strongly support the previous theoretical work and the writer is confident that the authors' theoretical approach to the problem, based as it is on extensive servomechanism experience, is the right one and that it will be extremely fruitful. It is intended to collect as many data as possible on the characteristics of existing plants and it is hoped in this way to build up a fund of information which will prove invaluable when new plants in the future are definitely designed to have the optimum characteristics for control purposes.

The writer feels that perhaps too much emphasis is placed in the paper on "command" disturbances, which are discussed at length in the authors' Appendix. While such disturbances occur frequently in servomechanism systems, for position control, etc., they are of comparatively rare occurrence in the automatic-process-control field and in general only occur when controllers are in cascade.

Finally, it is most interesting to note the emphasis which the authors place on automatic control on quality of product. The writer shares the conviction that control by analysis, as distinct from control on a physical condition, is very desirable and looks forward with interest to the development of new instruments for continuous plant analysis upon which to base such methods of control.

[6] Technical Department, Imperial Chemical Industries Limited, London, England.

AUTHORS' CLOSURE

The authors appreciate the contributions of the several discussions submitted on their paper. In particular, they appreciate the comments by Mr. Graff substantiating their remarks that in several areas much development of quality-measuring equipment will be needed before the control of quality becomes widely applicable. Simple and inexpensive quality control will, of course, not be achieved unless suitable standards and tolerances are established.

In view of the wide experience and background of Mr. Kerley in the process field, his remarks to the effect that system engineering and quality control are moving up the ladder are encouraging. This point is also expressed by Dr. H. L. Mason. However, Dr. Mason's comment that many chemical reactions and heat-exchanging processes are relatively slow compared with their instrumentation strikes the authors as debatable in relation to trends. Our thought is that as the principles of system analysis and design are, as mentioned by Mr. Kerley, given more attention, the development of more economical operations may bring about an increase in the speed of response of the process.

Mr. Miller has placed his finger on the two places in our scheme of things where action must originate. One is at the administrative level, for if engineers are not permitted to work as teams, system engineering is impossible. The war experiences of many of us saw much work co-ordinated at the contract level rather than at the technical level with consequent weakening of technical achievement. He also puts the finger on educators to provide the training adequate for these tasks. We are very cognizant of this.

Since preparing the original manuscript in the fall of 1948, the authors have seen privately more of the work referred to by Mr. Young. They are confident that the publication promised by Mr. Young will be welcomed by system engineers in the process field. The comment by Mr. Young relative to the authors' emphasis on the analysis of systems subjected to input commands was well taken. We intended to show that because the behavior of a feedback system with respect to load or output disturbances can be related to its behavior following command or set-point variations, the process-control problem can make good use of the wealth of servomechanisms literature and systematized techniques of analysis. Furthermore, testing of a system using set-point variations is often relatively easy and can yield data from which the regulatory action is easily investigated.

GORDON S. BROWN.[7]
DONALD P. CAMPBELL.[7]

[7] Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Characteristics of Greases as Applied to Antifriction Bearings

COMMENT BY MELVILLE EHRLICH[8]

This paper[9] gives an excellent summary of the different types of greases on the market. A grease manufacturer, by virtue of both testing and experience, must balance all characteristics of greases in an attempt to make the best product for any use being discussed. Different manufacturers use varied test procedures, and thus end with divergent recommendations for the same application. These recommendations are in themselves an indication that nobody knows all the answers; but that we are all trying to acquire the information which leads to the best products, properly applied.

The authors, in discussing greases, have mentioned a number of mechanical factors. In so doing, they have brought out indirectly a complex, costly, and discouraging problem which faces every grease manufacturer, namely, making sense of "complaints." When a grease is developed, it goes through laboratory testing. It is then placed under observation in the field, where the grease manufacturer may determine whether or not the product works. If it does not perform properly, the lubricant is withdrawn, reformulated in line with experience, and again sent into the field under careful observation. After thousands of pounds of lubricant have been observed and have performed satisfactorily under careful and highly critical control, the product is released for general distribution.

Every batch produced amounts to several thousand pounds of grease and thus will be placed in thousands of bearings. As more and more grease is made, the number of bearings lubricated with this product rises to the hundreds of thousands, and even millions. Out of all these lubricated points, one bearing occasionally burns out. The lubricant is usually blamed! In truth, how could the lubricant be at fault? With all the spots, numbered in the hundreds and thousands, in which even one batch of grease is used, complaints should arrive in floods.

Actual experience is contrary to this.

The existence of these individual spotted and patternless troubles then leads to a new train of thought. Was something really wrong with the grease? Or could it have been misapplied in some way? Or could some other mechanical factor, a few of which are listed in the following have been the chief bugaboo:

Design of Machine. Was the machine made easy to lubricate?

Was provision made for letting old grease out when fresh grease is added?

Are contaminants in the vicinity? If so, was adequate provision made for sealing them out?

Were bearings so enclosed as to run at excessive temperatures?

Are bearings adequate for the loads they must carry?

Condition of Machine. Is the machine just coming out of storage, or is it new, or in continued service?

What lubricant has been used previously? Was it cleaned out?

Are bearings new, just broken in, in good shape, or badly worn?

Operation of Machine. Does the machine run 24 hrs a day, 7 days a week; or 8 hrs a day 5 days, a week, or is its use only intermittent and occasional?

Is the machine run above, at, or way below rated capacity?

Are bearings subjected to unusual vibrations, or shock-loading?

Suitability of Lubrication Procedure. Is the machine lubricated on a regular schedule, suitable to the operation and application?

Are the lubrication personnel trained for the job?

Is the amount of lubricant just right, too much, or too little?

Is the correct lubricant used in each spot?

Is the entire lubrication program policed carefully? If not, amazing things can and do happen.

Why Is the Complaint Made? In order to eliminate a trouble spot?

In order to learn about a strange lubricant or application?

To cover a failure in engineering in the machine or in lubrication procedure?

All these and many more points must be considered. For as the authors have so ably indicated, greases are complex compositions. The manufacturer builds into his products an enormous amount of ability to perform. The question of whether or not the products do perform is dependent in part on the lubricant itself, but also on all the factors listed and on many more. These are the reasons that, in a discussion of greases, the authors have brought in so many apparently extraneous points, such as the amount of lubricant used, seals, clearances, relief plugs, length of storage of bearings or machinery, bearing design, and so forth.

The authors state clearly that "detailed information regarding operating conditions" is required. But it is the writer's feeling that this point should be brought out with more vigor, hence these comments.

A grease as a "material" can be described adequately in the manner which the authors have so clearly, carefully, and completely presented. But a grease as a "lubricant" seems to be inadequately described unless we include more information along the lines outlined herein.

COMMENT BY CHARLES R. GILLETTE[10]

The list of characteristics, covered by this paper, which are required in antifriction-bearing greases, is imposing. Admittedly, it is a difficult problem to combine them all into one product. However, the advances in grease technology in recent years have been extensive, and many products approaching these ideals are commercially available.

At the time of the introduction of ball bearings, having seals and shields combined as an integral part of the bearing and which also marked the introduction of prelubricated or "lubricated-for-life" bearings, poor oxidation characteristic resulting in bearings becoming "locked" in storage was one of the major causes of complaint. It is probable that in some instances corrosion of the metal occurred to the extent that the bearing surfaces were damaged irreparably as the authors point out. However, in general the obstruction to rotation appears to be caused by deposits of oxidation products of the grease which can be removed with suitable solvents. Rarely is there any visible attack of the bearing surfaces. Running such bearings until the deposits are broken up and admixed with the grease frequently will return them to a usable condition.

With the improvements which have been made in manufacturing practices and in oxidation inhibitors, poor storage life has ceased to be a problem, if bearings are stored under moderate conditions.

The rust-preventive characteristic of a grease is a factor needing further investigation and improvement, as well as test methods for its evaluation. Our observations coincide with the comments

[8] Chief Chemist, American Lubricants, Inc., Buffalo, N. Y.

[9] "Characteristics of Greases as Related to Antifriction Bearing Applications," by E. S. Carmichael and R. C. Robinson, MECHANICAL ENGINEERING, vol. 72, February, 1950, pp. 137-141, 143, 144.

[10] New Departure Division, General Motors Corporation, Bristol, Conn.

of the authors that superior rust-preventive characteristics are associated with products which tend to produce oil-in-water emulsions. However, it also appears essential for the emulsion to be capable of wetting the steel preferentially—both from the standpoint of rust prevention and lubrication. Many instances have been noted where severe corrosion has resulted from mild condensation when easily emulsifiable greases have been used, but which lacked the ability to wet the surfaces.

One factor which does not appear to be appreciated adequately is that many of the commonly used surface-active rust-preventive materials appear to hydrolyze, under appropriate conditions; actively promoting rather than retarding corrosion. More complete knowledge of this characteristic not only would result in improved ball-bearing lubricants but could be applied to soft-film rust preventives to considerable advantage.

In respect to film-strength additives, it is appreciated that, under certain conditions, particularly in roller bearings, an improvement in load-carrying ability is advantageous from the standpoint of providing better lubrication between the rolling member and the separator or retainer. While the authors are not specific on this point, it might be inferred that the reference to load is to that supported by the races. If this is the case, supporting evidence would be welcome, since it is not generally believed that film-strength additives are effective under the pressures present in the contact area.

COMMENT BY CARL T. HEWITT[11]

The descriptions of tests involved and the general "how and why" of ball-bearing lubrication make for a better understanding of the problems involved, both of the grease manufacturer and the ball-bearing maker and user.

Of outstanding interest and importance is that part of the paper dealing with the underlubrication and overlubrication with grease of antifriction bearings, since many bearing failures can be traced to this practice. It is well to keep in mind that, no matter how high the quality of the lubricant, over and underlubrication can cause bearing trouble.

No mention is made in the paper regarding friction oxidation and how this condition is influenced by the types of lubricants. Many ball bearings are used in applications where they are subjected to vibration while in a static or nearly static condition. We have found that certain greases are far superior in resisting this form of wear. Much work is presently being done along this line, and the outlook is very encouraging.

[11] The Fafnir Bearing Company, New Britain, Conn.

COMMENT BY E. M. KIPP[12]

Lubrication and its allied fields constitute a challenging and relatively new field of opportunity for top-notch engineering and scientific personnel.

This excellent paper points up in a significant and most effective manner the progress being achieved in the introduction and application of science and system to the art of the manufacture and use of grease-type lubricants. As consumers, we are vitally interested in the development of specific testing techniques which will enable us to select with good precision the best greases for the applications at hand. Characterization of the fundamental properties of greases by terms associated with specific and measurable characteristics is highly desirable.

The discussion of performance characteristics of greases in terms of engineering factors, such as, chemical stability, structural or effective viscosity, changes in physical properties, and the like, contrasts in a healthy and promising manner with the traditional emphasis upon vague and restricted information regarding composition, methods of manufacture, and other emphasis upon the "art" nature of the trade.

Among the several interesting and pertinent factors discussed by the authors, our attention was particularly drawn to the graphs presenting changes in viscosity with rate of shear. Although these changes have been recognized for some time, to the best of our knowledge, they have not been correlated directly with or employed as an investigational tool in the development of basic information relating to over-all performance characteristics of greases. For example, we would be very much interested in asking the authors whether the viscosity-rate of shear relationships are associated in any direct manner with the low and high-speed operating characteristics of greases. Are greases showing a high degree of variation in viscosity with rate of shear more or less likely to bleed? What relationships exist, if any, between the soap-micelle structure, oil viscosity, percentage of soap, etc., and the viscosity versus rate of shear relationships? Likewise, have any attempts been made to investigate changes in the consistency of greases with working on the basis of their fundamental viscosity-rate of shear properties? In this latter connection perhaps the worked penetration of greases will become more broadly useful if carried out under conditions representing more than one rate of shear. The authors already have stated a specific correlation of viscosity versus rate of shear properties with the pumpability of greases—an important and useful relationship.

The authors also give some interesting and pertinent data regarding degree of grease pack and temperatures developed in a bearing. This work is fundamental, and we would like to suggest that it could well be amplified to include simple investigations with reference to fluid frictional heat developed in a grease at various speeds of rotation. For example, we have noted in our own laboratories that, when rotating simple ball bearings immersed in a grease container at speeds of 10,000 rpm, temperatures as high as 350 F have been developed without application of any external heat whatsoever. Perhaps these heat effects would bear some direct correlation with the viscosity versus rate-of-shear properties.

We wish to commend the authors on their very timely paper and urge them to continue their work toward elucidation of the basic physical and chemical factors controlling the performance characteristics of greases. There is very definite need for multifunctional grease products in the consumer industry, and knowledge of the basic controlling characteristics with regard to grease structure and performance properties would play a vital role in permitting the formulation of greases with tailor-made properties.

[12] Chief, Lubricants Division, Aluminum Company of America, Aluminum Research Laboratories, New Kensington, Pa.

AUTHORS' CLOSURE

As indicated by Mr. Hewitt, no reference was made in the subject paper to friction oxidation, or as it is sometimes called "fretting corrosion." Deletion of this subject was considered advisable, since a treatment thereof would have extended the scope of the paper beyond the limits originally specified. Mr. Hewitt is entirely correct in implying that this phenomenon is highly important in many antifriction-bearing applications. It should be emphasized in this connection, however, that friction oxidation is not caused by the lubricant and, at the present time, cannot be completely prevented thereby. Generally speaking, friction oxidation can be reduced by employing a relatively soft grease in place of one of heavy consistency. If the grease tends to harden or "dry out," this type of corrosion may be more pronounced because of the absence of lubricating films between

vibrating surfaces. The subject of friction oxidation is one that is receiving considerable attention at the present time. As an example of the type of activity that is being carried out along this line, reference might be made to the cooperative work of the Coordinating Research Council. One of the principal objectives of this work is to develop a satisfactory laboratory-test method for differentiating greases with respect to their ability to minimize friction oxidation.

Mr. Ehrlich's emphasis on the importance of factors other than grease composition in determining lubricant performance is very much in order. As indicated in this paper, performance properties of any given grease are dependent upon factors such as amount of lubricant used, bearing seals, clearances, relief plugs, and so on.

A question has been raised by Mr. Gillette relative to the effectiveness of film-strength additives under pressures which occur in the contact areas of antifriction bearings. We are in complete agreement that load-carrying ability of the lubricant is advantageous from the standpoint of providing better lubrication between the rolling members and the separator or retainer. Our experience would indicate, however, that film-strength improving agents, such as extreme-pressure materials, are also beneficial in the load areas that support races under high-pressure conditions. We concur with Mr. Gillette that many film-strength additives, such as oiliness materials, are relatively ineffective in the latter areas because of the high pressures involved.

Dr. Kipp has presented a number of questions in his discussion which are of such a nature that a lengthy paper would have to be written to effect a complete coverage thereof. These questions, however, are of a basic nature, and it is through an understanding of considerations of this type that a better conception of grease characteristics will be obtained. It is hoped that the brief comments which follow will answer, at least in part, Dr. Kipp's inquiries pertaining to viscosity-rate of shear relationships.

(1) As shown in Fig. 2 of the subject paper, the apparent viscosity of a grease generally decreases as rate of shear increases. At low speeds where initial torques are large, greases may have relatively high viscosities and yet be entirely satisfactory in over-all performance properties. However, where starting and/or running torques are low for slow-speed operations, the apparent viscosity of the lubricant may be an important factor in determining the suitability of the product for the application. This fact has been recognized in the development and testing of aviation greases for low-temperature use. It is now common practice to obtain viscosity-rate of shear relationships at low temperatures and low rates of shear in order to predict performance properties that might be expected under service conditions.

An inspection of apparent viscosity-rate of shear data, particularly at different temperature levels, often serves to indicate the suitability of a grease for use in high-speed bearings. For example, if structural changes occur in the lubricant, which result in an abnormally large increase in viscosity, excessive plastic friction may be encountered with a subsequent objectionable rise in bearing temperature. In this connection it should be emphasized that the apparent viscosity-rate of shear relationship is only one of many factors which affect high-speed performance properties.

(2) There is no recognized relationship between bleeding of a grease and the degree of variation in viscosity with rate of shear. However, if two greases were prepared having identical chemical compositions and soap contents, but differed in stability against separation of oil bebecause of variations in processing, the more stable of the two greases would be expected to show the least change in viscosity with an increase in rate of shear.

(3) The viscosity-rate of shear relationship of a grease is dependent upon factors such as nature and quantity of soap, nature of mineral oil, and surface activity of the dispersed soap particles. In many cases, the effect of a change in one of the variables may be counteracted by altering another. For example, a reduction in soap content would be expected to decrease the rate of change of viscosity with increase in rate of shear. However, such a change may be counteracted entirely by the use of a different mineral-oil stock. The subject relationship is discussed to some extent in an article entitled "The Effect of Soap Structure on Apparent Viscosities of Lubricating Greases," which was published in *The Institute Spokesman*, vol. 10, no. 12, March, 1947.

(4) Relative to Dr. Kipp's question concerning grease working, it can be stated that the flatter the viscosity-rate of shear curve, the more stable is the grease against consistency change when subjected to mechanical working. Actually, at the present time laboratory tests frequently include mechanical working under different rates of shear. The ASTM grease penetrometer assembly can be employed for this purpose by using workers that have different-sized holes.

E. S. CARMICHAEL.[13]
R. C. ROBINSON.[13]

[13] Socony-Vacuum Laboratories, Socony-Vacuum Oil Company, Inc., New York, N. Y.

Housing and Spindles for Antifriction Bearings

COMMENT BY H. T. MORTON[14]

The problems involved in designing accurate spindles, which revolve on antifriction bearings, are treated comprehensively in this paper.[15]

Experience indicates that the amount of interference fit of an inner ring on a shaft depends upon the applied load which causes resistance to its turning. Since roller bearings carry greater loads for the same bearing size as ball bearings, their manufacturers recommend greater interference on shaft fits. Some precision ball bearings are mounted with line-to-line shaft fits and rely upon the shaft shoulders and locknuts to prevent slippage.

Similarly, most ball bearings have a few ten-thousandths looseness in their housings to allow the "floating" bearing to move axially, if there is a difference in temperature between the shaft and housing to cause heat expansion of the shaft with respect to the housing. With precision bearings made to close tolerances the need for lapping housings to obtain proper fits is lessened or eliminated.

Precision angular-contact ball bearings are manufactured with internal fits to maintain specific contact angles required for the operating conditions. To maintain these internal contact angles in service it is important that interference shaft fits should not change these angles

[14] Formerly Standards Engineer, The Fafnir Bearing Company, New Britain, Conn. Now President, Morton Bearing Company, Ann Arbor, Mich.

[15] "Housings and Spindles for Antifriction Bearings," by H. L. Blood, MECHANICAL ENGINEERING, vol. 72, February, 1950, pp. 131–133.

and, therefore, the line-to-line fits are generally recommended.

The author refers to the need of controlling accurate shaft location by means of preloads. He also asks for radial and axial deflection data on bearings under load. This information is not regularly published in bearing manufacturer's catalogues because of the limited number of spindle designers and the different requirements for each of them. These data are available or can be obtained on specific bearings as the need arises, so that designers can predetermine the effect of loads and avoid vibration which might cause chatter.

The author warns designers and spindle manufacturers of the pitfalls which must be watched to assure best bearing life, including the following:

Squareness of shaft and housing shoulders.

Push fits of outer rings.

Roundness of shafts and housings.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Analysis and Lubrication of Bearings

ANALYSIS AND LUBRICATION OF BEARINGS. By Milton C. Shaw and E. Fred Macks. McGraw-Hill Book Company, Inc., New York, N. Y., 1949. Cloth, $6^1/_2 \times 9^1/_4$ in., figures, tables, Appendix, References, and Selected Bibliography, pp. 596-611, xv and 618 pp., $10.

REVIEWED BY JOSEPH B. BIDWELL[1]

THIS book deals with the theory of bearing design and operation rather than with the art of bearing application. The coverage of the subject is unusually thorough in the field of internal-combustion-engine bearings. Inclusion of a complete table of, symbolic notation is commendable and, coupled with an excellent bibliography, makes the book a most useful reference for engineers in this field. Use of a large number of examples and a section of problems increases the value of the book as a text, though the subject is rather specialized for undergraduate study.

The first 143 pages of the book are concerned primarily with bearing loads in piston and turbine engines and dimensional analysis. The former subject is generally omitted from lubrication texts. The section on dimensional analysis is adequate and indicates its usefulness. The classical method of combining loads applied to each crankpin to determine the main-bearing loads of multicylinder engines neglects the stiffness of the crankshaft. The error introduced by this simplification is indicated by measurements made on a three-bearing single-row radial-aircraft-engine crankshaft. Calculation of the unidirectional loads encountered in gas turbines is considerably simpler and as shown by the authors the maneuvering loads are by far the largest. Current almost exclusive use of rolling-contact bearings in these units is indicative of the lack of information regarding operation of oil-film bearings under these conditions.

The authors' development of viscous flow through a capillary, Petroff's equation, and Reynolds' differential equation follow the usual form. These are followed by the analysis of tilting-pad sliders and journal bearings in two dimensions including solutions for load capacity and friction of these bearings. The chapter is concluded with a discussion of the limitations of the two-dimensional theory and the assumptions made in its development.

Dynamic loading has been seriously neglected by most previous writers and its importance to the design of bearings for piston engines has not been sufficiently stressed. The authors' analysis utilizes the same assumptions made in their discussion of two-dimensional theory but the operating characteristics thus calculated are compared with similar unidirectionally loaded bearings to minimize the effect of the assumptions.

The most general case of a bearing subjected to a load which varies both in magnitude and direction is shown to be insoluble in closed form. The two simpler cases of a rotating load of constant magnitude and a nonrotating bearing and journal subjected to a load varying in magnitude only are solved. The analysis of the operation of a piston-pin bearing presented by the authors based on their solution of the latter case is incorrect. Their method consists in substituting an "equivalent" sinusoidal load diagram for the actual bearing-load diagram. Selection of the equivalent load diagram is based on matching the actual diagram in the region of maximum load. In their example the equivalent load has a frequency six times that of the actual load diagram. Thus their load acts to force the journal toward its maximum eccentricity position for only 60 deg while from the actual load diagram it will be seen that the force is in one direction for about 570 deg. Since the resultant thickness of the "squeeze" film depends both upon the load and the time of application, their selection is hardly equivalent to the actual load.

Operating characteristics of journal bearings, including partial bearings, are considered in chapter 7. Here the authors consider end leakage, the extent of the oil film, position of the journal within the clearance space, bearing friction, oil flow, and temperature conditions in bearings. Experience causes this reviewer to disagree with Table 7-7, "Recommended Minimum Values of ZN/P and Sommerfeld number," on page 270. Sommerfeld number defines the minimum film thickness and, therefore, the minimum safe operating value is determined by the geometric accuracy of the bearing and journal as well as by the bearing material. Assuming equal geometric accuracy, softer bearing materials may generally be operated at lower values of Sommerfeld number. The authors' recommendation of a lower safe-operating value for copper-lead than babbitt is contradicated by their Fig. 7-13, which indicates that lead-indium overplated silver and lead overplated copper-lead reach their minimum coefficient of friction at a value of ZN/P about $^1/_2$ that for plain copper-lead.

Application of grooving, location of oilholes, and externally pressurized bearings conclude this chapter.

Parallel face, tilting pad, fixed pad, and composite thrust bearings are discussed in chapter 8. The analyses include the effects of temperature and vis-

[1] Research Laboratories Division, General Motors Corporation, Detroit, Michigan.

cosity variation in the oil film. The "Hydrosphere," a unique radial thrust bearing, is analyzed by the use of coordinates parallel and perpendicular to a stream line.

Operation of plain bearings at high speed and light load require consideration of turbulence in the oil film, oil-film "whirl," and erosion of the bearing material as pointed out by the authors. Though they recommend the use of a floating bushing for this type of operation, practical problems, such as starting the rotation of the bushing, have relegated its use to application involving boundary conditions as in wrist-pin bushings for two-cycle engines.

Ball and roller bearings are next discussed. Since in this type of bearing the loads are supported on very small contact areas between the races and the rolling elements, the stress at these contacts is one of the principal factors affecting bearing life. Modification of the load capacity by speed and type of loading is also discussed. The sources of friction in this type of bearing are pointed out and data on the effects of speed, load, and quantity of lubricant are presented for several styles of bearings.

Under the title, "Boundary Considerations," surface character and methods of measurement are described. The work and theories of Bowden and his associates are outlined in discussing dry friction. Properties of the principal bearing metals and their relative merits are also included. The chapter is completed by a discussion of mineral oils and synthetic lubricants, oil additives, and the various aspects of boundary lubrication.

In view of the difficulties encountered in including in an analysis all of the variables involved in a practical bearing installation, it has been found necessary to perform a large number of experiments. The last chapter is, therefore, concerned with the testing machines in use.

The remaining pages of the book are devoted to an appendix with tables useful for bearing load calculations, a problem section covering all chapters, a bibliography of three hundred and eighty-four references, and an index.

Scavenging of Two-Stroke-Cycle Diesel Engines

SCAVENGING OF TWO-STROKE-CYCLE DIESEL ENGINES. By Paul H. Schweitzer. The Macmillan Company, New York, N. Y., 1949. Cloth, 7½ × 10 in., 2 plates, tables, diagrams, illus., x and 268 pp., $7.25.

REVIEWED BY L. C. LICHTY[1]

THE two-stroke-cycle engine always has been an attractive type of engine since theoretically twice the output is possible compared to the four-stroke-cycle engine of the same size and speed. Actually, the difficulty in obtaining high scavenging efficiencies is the principal factor which has been responsible for the failure to obtain the possible increase in output. Consequently, Professor Schweitzer's book on scavenging should appeal to all interested in two-stroke-cycle engines and particularly those upon whom the responsibility rests for producing satisfactory engines of this type.

The author adheres closely to the subject, there being very little material that does not have a close relation to the intake system, the cylinder, and the exhaust system, and their effect on the scavenging process. The theoretical relationships in the various chapters are comparatively simple, the derivation of the more complicated equations being given in an appendix following the chapter in which the equation is used. This makes the text more readable and appears to be a very desirable procedure.

Charts have been developed for some of the more complicated equations and their use simplifies the solutions of various problems. This should appeal particularly to all actively engaged in the study and development of two-stroke engines.

Illustrative examples of various computations and design procedures are included and should be most helpful. Also, the combining of the elementary computations into a complete porting calculation in chapter 14 is a valuable feature. The determination in the complete computation of optimum inlet-port height for maximum output may leave the reader somewhat puzzled since the inlet-port height may be varied considerably while the computed output varies less than one per cent from the maximum, which is about the experimental error in output determinations.

The author recognizes that he has recommended the use of simple formulas and reduced the variables considered to a limited number because of the difficulty of analyzing the intermittent scavenging process. Also he is well aware, because of his practical experience, that the performance of the new engine on the test stand probably will not measure up to the expectations indicated by design computations; consequently he has included a chapter dealing with the experimental investigation of scavenging which should be of value in the development of the engine.

The word isentropic or the phrase "without friction" is omitted in the treatment of the blower-adiabatic-compression process without friction. This is common practice although it may mislead some. The word heat is used somewhat loosely in dealing with blower friction; however, the relationships developed are correct.

Confusion may result from the definition of mechanical efficiency in which the numerator (useful work) is defined in terms that make it equivalent to the indicated work of the Roots blower. Thus the useful work includes a large amount of friction effect. Consequently, the denominator of the mechanical-efficiency expression has this fluid-friction effect in the useful work in addition to the friction loss. This procedure results in mechanical efficiencies lower than the adiabatic efficiencies although it is stated that "mechanical efficiency . . . . . is usually expressed in terms of adiabatic efficiency."

Volumetric efficiency has served satisfactorily for the four-stroke-cycle engine but is found by the author to be anything but satisfactory for the two-stroke-cycle engine. Thus the term is avoided altogether for two-stroke-cycle engines. However, the author applies the term "charging efficiency" to the usual volumetric-efficiency definition.

The fuel-air ratio is based on the total air in the cylinder (i.e., including the air in the residuals) rather than on that part of the air which flows into the cylinder and is retained. As a result of this procedure the scavenging efficiency is introduced into the bmep equation which is used to prove (in a footnote) that the usual definition of volumetric efficiency is improper and leads to an absurd result. If the author had used the fuel-air ratio supplied the cylinder, the bmep relation would be a function merely of the charging efficiency, the supplied fuel-air ratio, and the specific fuel consumption; and as indicated heretofore, the charging efficiency is defined the same as the volumetric efficiency. However, this procedure would eliminate the scavenging efficiency from the bmep equation.

The reduction of volumes, in volumetric-efficiency determinations, to a standard condition results in variations

[1] Professor of Mechanical Engineering, Mason Laboratory, School of Engineering, Yale University, New Haven, Conn. Mem. ASME.

of volumetric efficiency with changes in barometric conditions. This is avoided by some who use the volume at manifold conditions. Charging efficiency is based usually on weight of air retained, which is the procedure followed by the author.

The book is well illustrated, the format being such that it is easy to read. There are some typographical errors but the corrections needed are usually very obvious to one at all versed in the subject.

A rather large bibliography (268 references) contains more than 140 references in foreign publications (principally German) and a rather large list of the author's publications, indicating his active interest in the subject as well as in fuel-injection and Diesel engines in general. If the bibliography was to include references dealing with fuel-injection systems, one wonders why the work of others in this field is omitted.

While a small number of points are subject to some criticism, the book as a whole is a valuable contribution, written by an author exceptionally well versed in the field and produced in a form that lends itself well to use.

Patent Practice and Management

PATENT PRACTICE AND MANAGEMENT FOR INVENTORS AND EXECUTIVES. By Robert Calvert. Foreword by Alan N. Mann. Scarsdale Press, Scarsdale, N. Y., 1950. Cloth, 6 × 9¼ in., plates, tables, Glossary of Terms, Appendix of Forms, Index of Cases and Authorities including Authors', Subject Index, xi and 371 pp., $5.

REVIEWED BY EDWARD GOTTLIEB[1]

THE value of this book lies in the novel point of view of the author, gained from his ten years' experience in industrial research, during which time he learned the problems and aspirations of the technical worker and executive. During this time he was employed by large corporations and was in intimate contact with the subject of patents. The author is a patent attorney and for the last fifteen years has been in general practice.

The book has discarded the general practice of abstracting court cases, dealing them into piles according to legal content, and then reviewing the decisions. Instead, hundreds of subjects that have come before the author through the years are discussed from personal experience and then his conclusions confirmed by reference to legal cases. The advantage of handling the subject in this manner immediately becomes apparent upon reading the book. For example, let us consider some of the chapters of the book.

Chapter 18 deals with "Secret Information, Hazards in Use and Modes of Protection." This chapter was selected for consideration because "secrets" are a fascination to everyone. Moreover, besides fascination, the information contained in this chapter is very valuable. In one of the situations discussed a person makes an invention but does not wish to spend money to protect it with a patent application and instead elects to disclose the idea as secret information to an engineer or other employee of a corporation, who in turn is influential in having the corporation adopt the idea. Did you know that the corporation is liable and must pay for the invention? Do you know the risks the inventor takes in a deal of this type? Do you know ways to protect the corporation?

The author's experience in large corporations and with the public makes it possible for him to create interesting and valuable situations, and his legal experience makes it possible for him to discuss legal protection of all parties concerned.

Take chapter 5—"Who Is the Inventor and Importance of Proper Selection." Here it is pointed out that in an organization with many scientific men working on an invention, there is a morale deterioration in the organization and legal defects in the patent, if the person to be credited with the invention and required to file the patent application is incorrectly chosen. Engineers and scientific men of the better class frequently deny any interest personally in appearing as the inventor, but the author has found that their inner feelings are contrary to their statements. This chapter is rich in considering the feelings and interests of all parties. Moreover, the most satisfactory way to pick out the inventor legally and morally to the satisfaction of all concerned is suggested.

The book contains 30 chapters, covering a wide field of practice and management of patents, and each of these chapters embodies the author's point of view. He is continually creating situations and discussing them in the light of his patent knowledge.

This book should make valuable reading for executives, engineers, and other technical personnel.

[1] Patent Attorney, New York, N. Y. Mem. ASME.

Books Received in Library

ASTM STANDARDS ON ADHESIVES, sponsored by ASTM Committee D-14. American Society for Testing Materials, Philadelphia, Pa., January, 1950. Paper, 6 × 9 in., 60 pp., diagrams, tables, $1.25. This compilation contains all fifteen ASTM Standards on adhesives. New material in this edition includes tests for impact strength of adhesives, strength properties of metal-to-metal adhesives in shear by tension loading, and cleavage strength of metal-to-metal adhesives.

ASTM STANDARDS ON PAINT, VARNISH, LACQUER AND RELATED PRODUCTS, prepared by Committee D-1; Specifications, Methods of Testing, Definitions of Terms. American Society for Testing Materials, Philadelphia, Pa. December, 1949. Paper, 6 × 9 in., 671 pp., illus., diagrams, charts, $4.85. Some 200 standards are included in this compilation of specifications, test methods, and lists of definitions for pigments; drying oils, paint driers, and thinners; shellac, varnish, and varnish materials; lacquer and lacquer materials; naval stores, and so on. Traffic paint-service tests and paint-weathering tests are covered. New material includes some 24 tests and specifications not previously published.

ASTM STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS, prepared by ASTM Committee D-2. American Society for Testing Materials, Philadelphia, Pa., 1949. Paper, 6 × 9 in., 1420 pp., illus., diagrams, charts, tables, $5.50 (cloth, $6.15). The 125 standards in this volume include test methods, specifications, lists of definitions, and tentative recommended practices. Twelve proposed methods of test are appended. Subject groups covered are petroleum fuels, illuminating oils, lubricating oils, plant spray oils, cutting fluids, insulating oils, hydrocarbon solvents, and ASTM specified thermometers. The methods of test for knock rating of engine fuels are not included in this compilation.

ADVANCED TIME-MOTION STUDY, Handbook of. By L. A. Sylvester. Funk & Wagnalls Company in association with *Modern Industry Magazine*, New York, N. Y., 1950. Cloth, 6 × 9¼ in., 273 pp., illus., diagrams, charts, tables, $5. Of value to industrial engineers and executives, this book presents human work in a three-dimensional concept—the product of mechanical work, physical conditions, and the human element. It discusses and defines what work is, the concept of a fair day's work, and within what limits of accuracy human work is measurable. Specific information is given on the mechanics of recording and evaluating time-motion study observations, the conduct of the time-motion study engineer, and the administration of the time-motion study activity.

ANNUAL REPORT ON THE PROGRESS OF RUBBER TECHNOLOGY, Vol. 12, 1948. Published by W. Heffer & Sons, Ltd., Cambridge, England, for the Institution of the Rubber Industry, London, England, 1948. Paper, 7¼ × 9¼ in., 108 pp., diagrams, tables, 12s6d. The current issue of this technical-literature survey covers the important aspects of the planting and production, chemistry and physics, and processing of raw rubber and other natural rubberlike materials. Separate chapters are devoted to synthetic rubber, cellular rubber, hard rubber, all of the major classes of rubber products, and testing. As customary, the selected bibliographies accompany their respective chapters.

APPLIED EXPERIMENTAL PSYCHOLOGY, Human Factors in Engineering Design. By A. Chapanis, W. R. Garner, and C. T. Morgan. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, Ltd., London, England, 1949. Cloth, 6 × 9¼ in., 434 pp., illus., diagrams, charts, tables, $4.50. Beginning with descriptive chapters on how human beings see, hear, and make movements, this book then applies these principles to the designing of machines and instruments better suited for human use. Psychological capabilities and limitations are effectively related to physical factors. Space is also devoted to the presentation of elementary statistical procedures and to a consideration of fatigue and other important physiological factors in the working environment.

COAL, COKE, AND COAL CHEMICALS. By P. J. Wilson and J. H. Wells. McGraw-Hill Book Co., Inc., New York, N. Y.; Toronto, Canada; London, England, 1950. Cloth, 6½ × 9¼ in., 509 pp., illus., diagrams, charts, tables, $8. This text is an authoritative treatise on coal, high-temperature coking, recovery of coal chemicals from coke-oven gas, and distillation of tar. Each phase of the industry is systematically covered, and other coal-carbonization processes, gas retorts, and lower-temperature coking are described briefly. Fuels, in general, and the principles of combustion, as well as the economics of the industry, are considered. A bibliography and a list of visual aids are included.

DEVELOPMENT OF AIRCRAFT ENGINE. By R. Schlaifer. DEVELOPMENT OF AVIATION FUELS. By S. D. Heron. Harvard University, Graduate School of Business Administration, Division of Research, Boston, Mass., 1950. Linen, 5½ × 8¼ in., 754 pp., diagrams, charts, tables, $5.75. This volume includes two extensive studies which focus on the important problem of government-business relationships. Among the patterns of joint development by government and industry, the authors consider the following: private enterprise using its own resources; industry financed by private funds; original research by government; and co-operative activity among the engine and oil industries and government units. Developmental work in the United States, England, and Germany is cited and compared.

DIESEL ENGINEERING HANDBOOK, 1950 edition, revised by the staffs of *Diesel Power* and *Diesel Transportation Motorship*. Published by Diesel Publications, Inc., New York, N. Y. Fabrikoid, 6 × 9¼ in., 725 pp., illus., diagrams, charts, tables, $7.50. As in the previous editions, detailed information is given on the Diesel-cycle, fuels, engine components, and auxiliary equipment. The principal revisions in this edition are the inclusion of outstanding new developments in the engine itself, its accessories, and in the application of Diesel power. Specifically, a short chapter has been added covering certain points of interest in marine use.

DYNAMICS OF REAL FLUIDS. By E. G. Richardson. Longmans, Green & Co., New York, N. Y.; Edward Arnold & Co., London, England, 1950. Cloth, 5½ × 8¾ in., 144 pp., illus., diagrams, charts, tables, $3.75. This book on hydrodynamics analyzes the following cases: Fluids of small viscosity, flow of compressible fluids, fluids with temperature gradient, a liquid having a free surface, fluids showing anomalous viscosity (suspensions), and elastic liquids. Footnote references to original sources are given.

ÉCHELLES DE CONVERSION DES UNITÉS ANGLO-SAXONNES EN UNITÉS MÉTRIQUES. By J. Bernot. Dunod, Paris, 1950. Paper, 7½ × 11¾ in., no pagination, charts, tables, 490 fr. Logarithmic comparison scales are given for the conversion of units from the metric to the English and American systems and vice versa. Units of length, area, volume, capacity, mass, force, pressure, velocity, acceleration, energy, temperature, heat, and miles per gallon are the items dealt with in this way. Skeleton tables of conversion factors for these and related units accompany the scales. Numbered half-scales are provided for the computer's own adaptations.

EFFECTIVE TEACHING, a Manual for Engineering Instructors. By F. C. Morris, prepared under the sponsorship of American Society for Engineering Education. McGraw-Hill Book Company, Inc., New York, N. Y., Toronto, Canada, London, England, 1950. Paper, 6 × 9 in., 86 pp., illus., diagrams, tables, $0.60. A guide for engineering instructors who are interested in the improvement of their teaching methods. It is designed to give first principles of good teaching and to point out some of the more common teaching faults. Definite directions are given for the effective handling of basic activities.

ELEMENTARY PILE THEORY. By H. Soodak and E. C. Campbell. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, Ltd., London, England, 1950. Linen, 5½ × 8½ in., 73 pp., diagrams, charts, tables, $2.50. Presenting a declassified version of the lectures given by Dr. Soodak during the Clinton Laboratories Training Program, this book discusses the fundamental ideas associated with the homogeneous chain-reacting pile in which fast neutrons are produced by fission. Only simple mathematics is used, and illustrations are included to facilitate understanding of the physical and mathematical ideas involved.

ELEMENTS OF INTERNAL COMBUSTION TURBINE THEORY. By H. T. Adams. Cambridge University Press, American Branch, New York, N. Y.; University Press, Cambridge and London, England, 1949. Cloth, 5½ × 8¾ in., 178 pp., diagrams, charts, tables, $3.75. Intended both for advanced students and engineers, this book presents the theory and some of the methods used in the design of the internal-combustion turbine. A background of the calculus and some knowledge of aerodynamics is assumed, but some fundamental material is given in the first chapter. Stress calculations, critical speeds, and heat exchange are among the special topics dealt with.

ELEMENTS OF PRACTICAL AERODYNAMICS. By B. Jones. Fourth edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, Ltd., London, England, 1950. Cloth, 5½ × 8½ in., 444 pp., illus., diagrams, charts, tables, $5. Intended as an introductory text, this book also provides a general survey of the practical aspects of the subject. In this edition, some nonpertinent material has been omitted; other material amplified, clarified, and rearranged; and all problems have been revised. In addition to elementary aerodynamics, the range of topics covers flight characteristics, engines, propellers, and control equipment. A knowledge of elementary calculus is assumed.

ENGINEERING FOR PRODUCTION. By W. Ernst, with an introduction by A. M. Greene, Jr. Research Press, Inc., Dayton, Ohio, 1949. Fabrikoid, 9½ × 11½ in., paged in sections, diagrams, charts, tables, $10. Linking the mechanical engineer and the workshop, this manual contains all the essential information required for the preparation of shop working drawings for structures, machines, and useful products. It provides a ready reference for useful engineering information and data design. In addition to drafting technique there are two sections on the characteristics of metals; threads and thread connections, gearing, and power transmission are also covered.

ENGINEERING MECHANICS. By A. Higdon and W. B. Stiles. Prentice-Hall, Inc., New York, N. Y., 1949. Cloth, 6 × 9¼ in., 505 pp., illus., diagrams, charts, tables, $6.65. This basic text stresses the fundamental principles of engineering mechanics and the development of the ability to apply them. Equal emphasis is placed on statics and dynamics. Where possible, an action is illustrated by the use of free-body diagrams or other pictorial and semigraphical aids as a supplement to the use of elementary calculus. Over 1100 problems are included, of which about 100 are set up as illustrative examples. The appendix includes answers to the even-numbered problems.

ENGINEERING REPORTS. By L. A. Rose, B. B. Bennett, and E. F. Heater. Harper & Brothers, New York, N. Y., 1950. Linen, 6¼ × 9½ in., 341 pp., diagrams, charts, tables, $3. Written for both the engineering student and the practicing engineer, this book deals with the problems connected with the conveying of facts and judgments on a technical level. It stresses the doctrine that effective reports are based on sound craftsmanship. Both written and oral reports of many kinds are considered, together with a discussion of the limitations as well as the virtues of each as a medium of communication. Every step in the process of preparing technical reports is developed. Unusual assistance is given with the preparation of illustrations and to nonbibliographic sources of information.

FIRE IN BUILDINGS. By E. L. Bird and S. J. Docking. D. Van Nostrand Co., Inc., New York, N. Y.; London, England; Toronto, Canada, 1947. Fabrikoid, 5½ × 8¾ in., 295 pp., illus., diagrams, charts, tables, $4.50. Addressed primarily to architects and town planners, this book states the principles of fire protection and explains the reasoning which underlies safety codes and fire regulations. Following a historical outline, the principles of fire growth and protection, causes of fire, means of escape, behavior of materials in fire, fire grading of buildings, and special types of buildings are discussed. Actual cases are used for examples. A bibliography is included.

FUNDAMENTALS IN THE PRODUCTION AND DESIGN OF CASTINGS. By C. T. Marek. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, Ltd., London, England, 1950. Cloth, 5½ × 8½ in., 383 pp., illus., diagrams, charts, tables, $4. This book stresses the fact that economy of production is a basic requisite of good casting design. Techniques, skills, and practices in casting production are all developed in a manner that supports this thesis. Important features include an over-all view of the casting industry, a description of basic molding processes, the theory of clay bond, a background in the principles of metallurgy, a description of high-voltage x ray, and supersonic inspection and modern theories on the melting of cast metals.

HANDBOOK OF CONVERSION FACTORS. By M. H. Green. Educational Publishers, St. Louis, Mo., 1948. Stiff paper, 4½ × 7¼ in., 88 pp., tables, $1.50. This small reference book lists conversion factors for some 250 units of measurement arranged in fourteen classifications—area, volume, time, electrical, and so on. The figures have been compiled

from various sources, chiefly from publications of the U. S. Bureau of Standards. Fundamental assumptions and definitions are given at the beginning of each section.

"HEAT INERTIA" IN PROBLEMS OF AUTOMATIC CONTROL OF TEMPERATURE. By V. Broida. Instruments Publishing Co., Pittsburgh, Pa., 1950. Paper, $5^1/_4 \times 8^1/_4$ in., 61 pp., diagrams, tables, $1. Originally published in French in 1942, and then in English in serial form in the magazine *Instruments*, this book discusses a method of solving process-control problems involving heat exchange without the use of computers. Part 1 contains a theoretical treatment of the method; Part 2 reviews the various continuous automatic temperature-control systems; and Part 3 provides a series of examples of practical applications of the method. A knowledge of elementary differential equations is assumed.

HEAT PUMP APPLICATIONS. By E. N. Kemler and S. Oglesby, Jr. McGraw-Hill Book Co., Inc., New York, N. Y.; Toronto, Canada; London, England, 1950. Cloth, $6 \times 9^1/_4$ in., 300 pp., diagrams, charts, maps, tables, $6. In nontechnical language, this book provides a practical discussion of the industrial, residential, and commercial applications of the heat pump, and considers its operation, performance, and potentialities. Both United States and European practices are treated. Basic theory, details of heat-pump elements, and temperature and design data are included. A final chapter is devoted to a patent survey.

INDEX OF NOMOGRAMS, compiled and edited by D. P. Adams. Published by John Wiley & Sons, Inc., New York, N. Y.; Technology Press of Massachusetts Institute of Technology, Cambridge, Mass.; and Chapman & Hall, Ltd., London, England, 1950. Cloth, $7^1/_4 \times 9^3/_4$ in., 174 pp., $4. This index lists over 1700 published nomograms in 97 important periodicals and thus serves as an invaluable timesaver in the repeated solution of mathematical formulas. It is divided into two main parts. Index A contains an alphabetical list of key words which are associated with each of the diagrams and a key number permitting reference to Index B where the periodical, date of issue, volume, number, and page of the nomogram are listed. Abbreviations of the variables employed in each diagram are listed at the beginning of Index B.

NONLINEAR VIBRATIONS IN MECHANICAL AND ELECTRICAL SYSTEMS. (Pure and Applied Mathematics, Volume 2.) By J. J. Stoker. Interscience Publishers, New York, N. Y., and London, England, 1950. Linen, $6 \times 9^1/_4$ in., 273 pp., diagrams, charts, tables, $5. A connected and systematic account of the theory and techniques of nonlinear vibrations occurring in systems with one degree of freedom. The author emphasizes the various known types of physical problems in the field. For most of the book a knowledge of ordinary differential equations is sufficient, but more rigorous mathematical treatments are developed in the accompanying appendixes.

OPERATION AND CARE OF CIRCULAR-SCALE INSTRUMENTS. By J. Spencer. Instruments Publishing Co., Pittsburgh, Pa., 1949. Cloth, $4^1/_2 \times 8$ in., 90 pp., illus., diagrams, $1.50. A reprint in book form of a series of articles which appeared in the magazine *Instruments*, this manual covers both d-c and a-c instruments, including electrodynamic types, power-factor meters, and synchroscopes. Trouble charts and a check list of essential tools and equipment are provided.

ORGANIZATION OF INDUSTRIAL SCIENTIFIC RESEARCH. By C. E. K. Mees and J. A. Leermakers. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y.; Toronto, Canada; London, England, 1950. Linen, $6 \times 9^1/_4$ in., 383 pp., diagrams, charts, tables, $5. This book presents an account of the history and development of industrial scientific research, the general principles of its conduct, and the methods actually used for the organization of industrial research laboratories. Detailed information is provided on the selection of a program, the direction of research, the financial administration of the laboratory, and a number of auxiliary services. Data are included on the design of a laboratory for a specific industry. Examples are cited of government and large-industry procedures.

PATENT PRACTICE AND MANAGEMENT for Inventors and Executives. By R. Calvert, with foreword by A. N. Mann. Scarsdale Press, Scarsdale, N. Y., 1950. Cloth, $6 \times 9^1/_2$ in., 371 pp., illus., $5. Beginning with a discussion of "what to patent," this book goes on to present not only the essentials of patent law but also a wide range of associated problems which may have to be dealt with under various conditions. The emphasis is on procedures for obtaining patents, using them, and administering the patent policy to stimulate research, invention, and morale.

PHOTOELASTICITY, Principles and Methods. By H. T. Jessop and F. C. Harris. Dover Publications, New York, N. Y., 1950. Linen, $6^1/_4 \times 9^1/_2$ in., 184 pp., illus., diagrams, charts, tables, $3.50. Written for those who wish to undertake practical work on stress exploration, this book emphasizes principles and their application in the derivation of the standard equations and in the devising of appropriate methods of procedure. It is not intended to be a treatise on the theory of photoelasticity. Stresses, strain, and stress-strain relations, optics, polarization and double refraction, reduction and interpretation of observations, stresses in three dimensions, equipment, materials, and procedures are covered.

PHYSIQUE INDUSTRIELLE. By J. Izard. Twenty-seventh edition. Dunod, Paris, France, 1950. Cloth, 4×6 in., 430 pp. plus tables, 46 pp., illus., diagrams, charts, 350 fr. This pocket-size useful handbook contains numerical and other data frequently wanted by engineers engaged in combustion, hydraulics, automotive, heating, chemical process, ventilating, and illuminating engineering. A bibliography of recently published French books in the field of applied physics adds value.

PRINCIPLES AND PRACTICE of Flow Meter Engineering. By L. K. Spink. Seventh edition. Foxboro Company, Foxboro, Mass., 1949. Cloth, $5^1/_4 \times 8$ in., 418 pp., illus., diagrams, charts, tables, $7. This book serves both as a source of important flow data and a guide to correct methods of measuring flow. Part 1 covers all phases involved in the measurement of any liquid with an orifice, flow nozzle, Venturi tube, or other devices. In Part 2, calculations in weight units of compressible fluids are considered. Part 3 contains the calculation procedure developed especially for the measurement of fuel gases but is adaptable for any gas which reasonably conforms to the perfect-gas laws.

PRODUCTION PROCESSES, Their Influence on Design. Volume 1. By R. W. Bolz. Penton Publishing Co., Cleveland, Ohio, and London, England, 1949. Cloth, $6^1/_2 \times 10^1/_4$ in., 568 pp., illus., diagrams, charts, tables, $10. This book presents a broad study of the many manufacturing processes utilized in the production of any and all types of machine components. In the design of machine parts special emphasis is directed to features which insure simple and economical processing. Following an outline of basic rules, detailed consideration is given to metal-removal, metal-forming, metalworking, and metal-deposition methods. A subsequent volume will cover other processing methods.

RATIONALISIERUNG ALS WELTBEWEGUNG im Spiegel ihrer Begriffslehre. By H. von Haan. Orell Füssli Verlag, Zürich, Switzerland, 1949. Paper, 6×9 in., 81 pp., 6 Sw. fr. Portraying scientific management as a world movement, this book presents a survey of the various systems now in use. It also provides a comparison of English, French, German, and international terminology. The principal doctrines and laws of scientific management are also discussed.

RESIDUAL STRESSES IN METALS. (Edgar Marburg Lecture, 1949.) By W. M. Baldwin, Jr. American Society for Testing Materials, Philadelphia, Pa., 1949. Paper, $6 \times 9^1/_4$ in., 45 pp., illus., diagrams, charts, tables, $1. This lecture covers the fundamental differences in the mechanism by which residual stresses are developed by cold-working operations, by heat-treatment, and by casting and welding. Also discussed are experimental test methods, residual-stress patterns, and effects of the elimination of residual stress.

STAHLHOCHBAU, Band 1. By C. Kersten. Fifth edition. Verlag von Wilhelm Ernst & Sohn, Berlin, Germany, 1949. Paper and bound, $6 \times 8^1/_4$ in., 234 pp., illus., diagrams, tables, paper, 14 Dm; bound, 15.60 Dm. This standard work is now divided into two volumes. The first volume of this fifth edition covers classification, strength, and shop fabrication of iron and steel, structural diagrams and weight calculation, riveted and bolted fastenings, arc and spot-welded connections, beam supports and columns. New illustrations, modern usage, and examples of calculations have been added.

STRESS AND STRENGTH OF MANUFACTURED PARTS. By C. Lipson, G. C. Noll, and L. S. Clock. McGraw-Hill Book Co., Inc., New York, N. Y.; Toronto, Canada; London, England, 1950. Cloth, $6 \times 9^1/_4$ in., 259 pp., diagrams, charts, $4.50. Written for designers, engineers, and metallurgists, this book provides specific data for the prevention and elimination of failures in manufactured parts and assemblies. Part 1 briefly discusses the general principles underlying the basic concepts of the balance between stress and strength. Part 2 contains 175 charts giving graphical representations of stress-concentration factors and allowable stress data. An appendix provides references and supplementary data for Part 2 and a chronological bibliography with an author index.

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THE ENGINEERING PROFESSION

News and Notes

As Compiled and Edited by A. F. Bochenek

EJC Aid Asked by NSRB in Specialized Technical Man-Power Problems

THE Engineers Joint Council at its meeting in New York, N. Y., on May 19, 1950, heard Robert L. Clark, director, Office of Man Power, National Security Resources Board, discuss specialized technical man-power problems relating to national defense, during which he asked the EJC Societies to co-operate in providing qualitative data on available engineering skills in their respective specialities. The Council also took up such matters of general interest to the engineering profession as recommendations for a national water policy, establishment of local sections of EJC societies outside the limits of the United States and its possessions, co-operation in medical research, and others.

The key to success in any national defense effort, Mr. Clark declared, was, first, adequate man power, and second, control of waste of available skills. In planning for future war emergencies, he said, his office had to know the requirements of the Armed Forces and industry for specific occupational skills. The engineering societies could help the Government by developing the questions which would provide this information. The EJC could help in yet another way, he added. EJC societies could give qualitative data on available engineering skills. Such data could not be obtained from the punch cards of scientific roster because these give only quantitative data.

With reference to deferment of engineers in a future war, Mr. Clark stated that his office is "working out a policy." Here again, he said, basic information on requirements and resources was lacking. A new concept of "reservation of skills" was under consideration. This envisaged creation of man-power pools of rare or short-supply skills from which the military and industry could draw upon by requisition.

His office was aware, he said, of the danger of indiscriminate calling up of the reserve officers, many of whom held key jobs in industry.

Referring to the current survey of scientific and engineering personnel being conducted by the EJC for the Office of Naval Research, Mr. Clark noted that until the recent enactment of a bill establishing a National Science Foundation, there had been no place in the Government to obtain data on scientific man power. The EJC survey would provide useful roster until the Foundation could take up the task.

National Water Policy

W. W. Horner, chairman, EJC National Water Policy Study Panel, reported that about 90 engineers drawn from the five EJC Societies and several other national groups were at work on a draft of recommendations to the President's Temporary Water Resources Commission. As of May 18, three of the nine task force committees had completed their drafts, and the others were expected to complete their work by June 1 in ample time for submission of the final statement to the Commission.

Following a discussion of the propriety of establishing local sections of EJC societies outside the limits of the United States, it was agreed to recommend to EJC societies that such sections be authorized only under one of the following conditions: (1) When the interest of the local group was not embraced in that of any national engineering society of its own country, and (2) only with the knowledge and acquiescence of the national engineering society, if it covers the same field as that of the local groups desiring local-section status.

The Committee on Engineers Co-operating in Medical Research reported that a number of engineers offered assistance in medical research following a published account of an informal summer meeting of doctors and engineers at the Cornell Medical Center in 1949. These offers are to be called to the attention of departmental heads of medical-research centers in the New York area with a request that they refer to the EJC any problems, especially those involving repetitive operations, amenable to mechanization. The Committee plans to arrange meetings between individual doctors and engineers.

Another Employment Survey Suggested

The Council also discussed the report of the U. S. Department of Labor which indicated a present and prospective scarcity of jobs for engineers. It was the consensus that the report was grossly misleading. L. E. Young, president EJC, suggested that the General Survey Committee make a quick survey for early release giving a picture of the job situation of those who have recently graduated.

Upon conclusion of official business, Hartley W. Barclay of *The New York Times*, spoke briefly on invitation from President Young. Mr. Hartley expressed appreciation at being invited to the meeting and said that America owed so much to its engineers that newspaper men realized it was the biggest story the press had to tell. He offered to co-operate in every way possible in getting the engineer's story to the public in accordance with the high standards set by the engineering profession.

Science Foundation Becomes Reality

AFTER more than five years of effort on the part of Congress, Engineers Joint Council, and others, the National Science Foundation became a reality when President Harry S. Truman signed Bill S.247 while on his recent trip to the West Coast.

The act creates the foundation as an independent agency in the executive branch of the Government. It will be headed by a board of 24 eminent scientists and engineers, and a director, all appointed by the President with the consent of the Senate.

The act authorizes the Foundation to (1) develop and encourage the pursuit of a national policy for promotion of basic research and education in the sciences; (2) initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences; (3) at the request of the Secretary of Defense to support research relating to national defense; (4) award scholarships and graduate fellowships in engineering and other sciences; (5) foster interchange of scientific information among scientists in the United States and foreign countries; (6) evaluate and correlate any research programs undertaken by other agencies of the Federal Government; (7) establish special commissions if necessary to carry on its functions; and (8) maintain a register of scientific and technical personnel, and to serve as a clearinghouse for this information in the United States and its territories and possessions.

For the fiscal year which ended June 30, 1950, the act provides an appropriation of $500,000, and for each fiscal year thereafter a sum not to exceed $15,000,000.

Since much of the work of the Foundation will have to do with applied science, the Engineers Joint Council has suggested to John R. Steelman, assistant to the President, that at least six of the 24 board members be engineers.

A list of engineers who are qualified to serve in this capacity was presented to Dr. Steelman as the recommendation of the EJC.

In signing the bill, President Truman said that the United States knew that its ability to survive and grow depended largely on its scientific progress. It was not enough to keep abreast of the rest of the world in scientific matters. We must maintain leadership he said. "The nation's strength is being tested today on many fronts. The National Science Foundation faces a great challenge to advance basic scientific research and to develop a national research policy. Its work should have the complete support of the American people."

MAPI Meeting on Replacement Policy

SEVERAL hundred industrial executives from the New York area listened to explanations of the application of a formula to determine when to replace worn-out or obsolete machines at a luncheon meeting held in New York, N. Y., on May 23, 1950, under the auspices of the Machinery and Allied Products Institute, at the Waldorf-Astoria. William J. Kelly, president of the Institute and senior partner of William Kelly and Company, a Chicago management-counsel firm, presided. The meeting was one of a series being held in principal cities to put the Institute's recommendations on scientific replacement into practical use in industry.

Duncan J. Stewart, vice-president, Barber-Colman Company, Rockford, Ill., described application of the MAPI formula in his own company. He emphasized the costliness of continuing to use machinery which should be replaced. He said that in his company a small staff of analysts is charged with the responsibility of keeping the management advised on needed replacements. It is this staff's duty not only to know the performance of present equipment, but also to be familiar with the best available alternative at all times.

He cited one instance where the department had found that a machine could do work formerly done by hand.

Opportunity Overlooked

"The gain in production and in lightening the load of the workman is terrific and it is amazing to realize that we have overlooked the opportunity for the last ten years," he said.

He cited another instance where a similar saving was possible but in this instance the machine is a new development, and therefore there was no superior alternative until about 12 months ago.

"One weakness in replacement," Mr. Stewart said, "is that management fails to investigate sufficiently all possible alternatives. We consider replacing one machine with another like it when we also ought to look into the possibility of doing the machine's job in some entirely new way. Investigation like this requires more personnel continuously engaged in such activities. Providing such personnel for replacement analysis pays off in handsome profits which will lead to better working conditions."

George Terborgh, research director of the Institute, highlighted the theory behind the MAPI formula and said that industry's current replacement policies are based on folklore rather than science. He is the author of two recent books in the field, "Dynamic Equipment Policy"[1] and "MAPI Replacement Manual."

29 Factors to Be Considered

A case example was presented in detail by Everett M. Hicks, assistant manager, Grinding Machine Division of the Norton Company, Worcester, Mass. Each man at the meeting had before him a one-page form with blanks for twenty-nine different factors to be considered in making a decision on replacement. Mr. Hicks then presented the facts about two 10-year-old grinding machines which he proposed to replace with one modern grinder.

The analysis covered such factors as interest, taxes, salvage value of the old machine, labor cost that could be saved by the new machine, saving in floor space, power, and the like.

A basic objective of the procedure was to determine which would be most profitable to the owner during the next year—the two machines now in operation or the best available replacement.

"In replacement analysis we face two alternatives," he said. "We can keep the old machine and keep down capital cost but accept a higher operating cost. On the other hand, we can seek mechanical perfection for the moment, but at increased capital expenditure.

"Here is the key to correct equipment policy. To reach a correct decision when considering new machines to take the place of old, we must compare the sum of operating inferiority and capital cost for the present equipment with that of the proposed equipment. Our decision will be in favor of that equipment which gives us the smaller total of inferiority and capital cost."

Mr. Hicks explained that engineers in any company can quickly be trained to apply the MAPI formula, and thereby determine when the machine is economically dead and due for replacement for economy of production.

[1] A review of this book will be found on page 510 of the June issue.

Department of Defense Host to Engineers

ABOUT 80 members of the five national engineering societies that make up the Engineers Joint Council attended a joint indoctrination conference held at the Pentagon Building, Washington, D. C., on May 11, 1950, at the invitation of the Department of Defense. The subject of the all-day conference was "The Current International Situation." The object of this conference was to give engineers, who have an interest in the scientific phases of preparedness, an opportunity to obtain a broad view of this field and to participate in a confidential and off-the-record discussion of certain phases of the international situation.

Presiding over the conference was Lieut. Commander Clarence Cisin, U. S. N., who spoke of the possibility of close public relations between the Department of Defense and the engineering societies and of the ways in which it was possible to assist in the dissemination of national-defense news. He suggested that the engineers form a committee to work closely with the Department of Defense toward these ends.

The engineers were welcomed to the conference by Col. E. B. LeBailly, U.S.A.F., chief, National Organization Branch, Office of Public Information, Office of Secretary of Defense. Colonel LeBailly said that it was the function of the Branch to get public opinion and pass it on to the Department of Defense.

Other speakers at the morning session were: The Honorable Paul Griffith, Assistant Secretary of Defense; Paul H. Nitze, director, Policy Planning Staff, State Department, whose topic was "Plans and Problems of Foreign Policy;" Major General Lymann Lemnitzer, U.S.A., director, Office of Military Assistance, Office of Secretary of Defense, who spoke on "Application of the Military Aid Program;" Felix Larkin, General Council, Department of Defense, who described "Unification;" and Brigadier General Delmar T. Spivey, U.S.A.F., chief, War Plans Division, Directorate of Plans and Operations, who explained "Air Defense of the U. S."

At the afternoon session Dr. D. S. Cornell, director, Planning Division, Research and Development Board, told about the Research and Development Program. He listed six important problems on which ideas for solution were needed and asked the engineers to send their suggestions to the National Inventors Council of the Department of Commerce. The last speaker was Rear Admiral Frederick E. Haeberle, U.S.N., assistant chief, Bureau of Ships, Department of the Navy, who told about the "Navy's Postwar Shipping and Conversion Program."

At the close of the Conference, Alex Bailey, past-president ASME, expressed the thanks of the engineers on behalf of all present and EJC.

Engineers Need More Speech Training

INDUSTRIAL and business leaders recommend speech training for engineers, according to Albert A. Rights, assistant professor of English at Lehigh University, Bethlehem, Pa., who addressed more than 300 delegates attending a regional meeting of the American Society for Engineering Education, Lehigh University, May 13, 1950. His address, "What Industry and Business Expect of College Trained Men in Oral Communication," was based on a recent survey of over six-hundred responses and interviews of leaders in industry and education.

Reporting the findings of the survey sponsored by the Lehigh University Institute of Research, Professor Rights said that industry and business "have been searching for the explanations of the many failures of college-trained men and women to express themselves adequately in oral and written communication. These failures have extended from the writings of work-progress reports to the complex give-and-take of labor-management mediation.

"Although in recent years liberal electives for speech training have been available to engineering students, few have taken advantage of these courses because of the great demands of the scientific curriculum. Industrial leaders believe this neglect should be remedied. They suggest that specialized communication teachers be developed within the curriculum of engineering, and that co-operation of the teachers of engineering courses be urged as much as possible."

Professor Rights outlined the scope of the survey as (1) the validity of the criticism of

industrial and business leaders; (2) the causes for the criticism; (3) the present practices of colleges in teaching oral communication for engineering and business students; (4) what industry and business leaders expect college men to learn in basic and advanced oral-communication skills for their professional needs; and (5) what various individuals of industry have found of most value in their personal training of communication skills.

The survey revealed that engineering students as a group got less training in oral communication than any other group. "Essentially industry has been assuming some of the burden of training college engineers in communication skills. The majority of executives and supervisors of training programs do not favor this responsibility," Professor Rights said.

"Industrial leaders place much emphasis upon correlation of visual demonstration with speech materials, business dictation, and vocabulary building. According to executive management, more could be done in the integration of writing and speech training. Management also recommends that courses in personnel administration, industrial management, and engineering conference should be more closely integrated with communication training."

Unification on Bolts, Nuts, and Cap Screws Subject of Two-Day Conference

AGREEMENTS on standards for bolts, nuts, and cap-screw dimensions which, if adopted, can mean virtually complete unification of British and Canadian standards with American standards were concluded at a Conference which met in the Hotel New Yorker and the Engineering Societies Building, New York, N. Y., June 2-3, 1950.

A 12-man British and a five-man Canadian delegation representing trade and technical societies, industry, and the armed forces of those countries, meeting with the Sectional Committee on Bolts, Nuts, and Fasteners of the American Standards Association, agreed to recommend to their respective countries two new series of bolts, nuts, and cap screws for heavy-duty machinery and a selection based in all but one case on present proposed American standards for either regular or light series.

The dimensions discussed at the conference were mostly for hexagon-head bolts and nuts for which the threads are already unified. The range of sizes agreed upon is intended to achieve greater simplification. All of the enormous benefits of interchangeability deriving from the unification of screw threads which these three countries accomplished almost two years ago would be intensified if the recommended series are adopted by Britain and Canada. The belief is that they will be.

The conference was a result of a proposal by British standards authorities made in October, 1949, suggesting that the remaining differences in the standards of the three countries be discussed over a conference table. These differences were causing difficulties because bolts and nuts on American military equipment and industrial goods could not be replaced in Britain with English nuts and bolts. While the unified American standard had brought agreement to the screw threads, no such agreement was yet in effect on size ranges of American and British nuts and bolt heads.

The British delegation was headed by Sir Anthony Bowlby of the British Bolt, Nut, Screw, and Rivet Conference. J. G. Morrow, chairman, Canadian Standards Association, headed the Canadian delegation. American interests were represented by a group headed by H. W. Robb, standards division, General Electric Company, Schenectady, N. Y.

ASM Selects New Officers

AT THE annual meeting of the American Society for Metals the nominating committee named the following to serve as officials for the year 1950-1951: president, Walter E. Jominy, staff engineer, Chrysler Corporation; vice-president, Dr. John Chipman, head, department of metallurgy, Massachusetts Institute of Technology; secretary, W. H. Eisenman, renominated for the 17th consecutive two-year term; and treasurer, Ralph H. Wilson, Mem. ASME, chief metallurgist, Timken Steel and Tube Company, Canton, Ohio.

Engineering Literature

Screw Threads

THIRTEEN pages of addenda to the American Standard Unified and American Screw Threads ASA B1.1-1949, were recently made available to purchasers of the first printing of the standard. The addenda are designed to be cut up and pasted into the first edition. When this is done, the standard will correspond to a second edition which is now available to those who do not have a copy of this standard.

The addenda includes a preface to the second edition which states:

"The original printing of this standard has been exhausted. It was agreed by the Standing Committee on Unified and American Screw Threads, B1, that such errors as have been found should be corrected in the second printing and that some editorial revisions should be made to eliminate inconsistencies and otherwise clarify the standard. This corrected and revised reprint is designated 'Second Edition.'

"Changes of primary interest to the user of the standard are: (1) Inclusion of the 1 in. 14 NF size as an optional American Standard in the fine thread series; (2) introduction of the designation 'UNEF' for certain sizes of the extra-fine thread series; (3) deletion of the 1/2 in. 12 NC and 1 in. 12 NF threads from Classes 2 and 3; (4) correction of the headings of Table 26; and (5) revision of 'Limitations of Design' on page 87. Neither these changes nor numerous other minor changes made to improve the standard should impair significantly the usefulness of the original printing to those who possess it."

Price of addenda is 50 cents; that of the second edition, $3.

Twist Drills

AMERICAN Standard on Twist Drills, Straight Shank and Taper Shank (ASA-B5.12-1950) was recently published by The American Society of Mechanical Engineers. This standard is a revision of the 1940 issue which did not satisfactorily meet the requirements of twist-drill users. In the new edition (1) tolerances have been set on the various features of drills to make the products of different manufacturers interchangeable, (2) taper-shank drills have been included, (3) the sequence of diameters of straight-shank drills was changed to correspond to the actual sizes purchased and used in industry, and (4) lengths of number, letter, and fraction-size drills were changed so that all three series have corresponding lengths. The standard covers straight-shank drills varying in diameter from 0.0135 to 2.000 in., and taper-shank drills from 1/8 in. to 3 1/2 in. The tolerances are given on drill diameter, shank diameter, back taper, over-all length, and flute length. Price is 75 cents.

Die Sets

AFTER many draft revisions, the American Standard Punch and Die Sets, ASA B5.25-1950, has finally been approved and published as an American standard by The American Society of Mechanical Engineers. The 14-page standard covers the design and dimensions for two series of two-post, punch-press, tool-die sets, consisting of back-post and diagonal-post sets. In addition to a section on definitions, the standard includes a table of tolerances for die sets, tables of dimensions of back-post and diagonal-post sets, as well as shank diameters and lengths, and guide-post bushings. Price is 75 cents.

Worm Gearing

DESIGN for Fine-Pitch Worm Gearing, B6.9-1950. This new Standard is intended as a design procedure. It covers worms and worm gears with axes at right angles, comprising cylindrical worms with helical threads, the worm gear being hobbed for fully conjugate tooth surfaces.

It supplies the standard proportions of worms and worm gears, values of diameter for all possible combinations of leads and lead angles within the Standard, and tooth proportions based on normal pitch for all combinations of standard axial pitches and lead angles. An extensive table gives the difference in departure from a straight side of the worm profile and the changes in pressure angle produced by cutters or grinding wheels of 2-in. and 20-in. diameters. (Values in this table are diagrammatically illustrated.) Examples of fine-pitch worm and worm-gear calculations are included to assist the designer in using the standard. Sketches show (1) throated worm-gear blank (for power drives) and (2) non-throated worm-gear blank (for transmission of motion). Price is $1.50.

Copies of these Standards may be obtained

from the Order Department, ASME, 29 West 39th Street, New York 18, N. Y.

Ball and Roller Bearings

A NEW 12-page American Standard on "Gaging Practices for Ball and Roller Bearings" was published recently by American Standards Association, 70 E. 45th Street, New York 17, N. Y. It is the first of a series under development by a committee representing 14 associations of engineers, industrial users and manufacturers of bearings, and the U. S. Army and Navy.

The standard specifies the most acceptable methods of determining whether bearings conform to specified dimensions. Specifically, it defines inspection methods, giving gaging loads and methods of measurement. Standard methods are given for obtaining dimensions of inner and outer rings, parallelism of sides, eccentricity, groove parallelism with sides, and other significant measurements. It also prescribes methods of measuring internal fit and tolerances for side run-out of lock nuts. Price is 50 cents per copy.

People

W. F. Perkins Elected ASME Fellow

WALTER FREDERICK PERKINS, industrialist, vice-president and general manager, Metal Products Division, Koppers Company, Baltimore, Md., was recently elected to the grade of Fellow ASME. Mr. Perkins was born in Baltimore, Md., June 3, 1891. He received a CE degree from Lehigh University in 1913. In 1914 he went with the Bartlett Hayward Company when that company had just contracted to produce artillery ammunition for the Russian government. Upon the entry of the U. S. into World War I, all facilities were turned over to the government and a tremendous expansion of activity took place.

Mr. Perkins was made personally responsible for the manufacturing and engineering activities incident to the program.

Later, after the Bartlett Hayward Company became part of the Koppers Company, he was made vice-president and general manager, the position he now holds, and was placed in complete charge of all operations. In 1942 he was requested by Paul McNutt, then chairman, War Manpower Commission, to organize the first regional man-power commission. Mr. Perkins has always taken an active part in the civic projects of Baltimore and currently is chairman, Mayor's Advisory Committee on the Budget and of the Airport Board.

To be qualified as a nominee to the grade of Fellow one must be an engineer who has acknowledged engineering attainment, 25 years of active practice in the profession of engineering or teaching of engineering in a school of accepted standing, and has been a member of the Society for 13 years. Promotion to the grade of Fellow is made only on nomination by five Fellows or members of the Society to the Council to be approved by Council.

* * *

GANO DUNN, Fellow and Hon. Mem. ASME, president of Cooper Union, was presented the second Peter Cooper Medal awarded to a trustee, in recognition of 25 years of service.

* * *

RALPH L. GOETZENBERGER, Fellow ASME, was elected chairman of the Citizens Federal Committee on Education, a lay advisory committee to the U. S. Commissioner of Education. Mr. Goetzenberger represents the Engineers' Council for Professional Development on the Citizens Federal Committee.

* * *

JOHN W. VANDERWILT was appointed president of the Colorado School of Mines, Golden, Colo., it was recently announced by the board of trustees of the school.

* * *

FREDERIC H. KELLOGG, chairman of the department of civil engineering, was recently appointed dean, school of engineering, University of Mississippi.

* * *

CARL E. SCHMITZ, Mem. ASME, vice-president, director of engineering, Crane Packing Company, Chicago, Ill., was elected vice-president-at-large of the American Society of Lubrication Engineers at the annual convention held in Detroit, Mich.

* * *

HARVEY N. DAVIS, Hon. Mem. and past-president ASME, plans to retire as president of Stevens Institute of Technology on Sept. 1, 1951.

* * *

BLAKE R. VAN LEER, Mem. ASME, president, Georgia Institute of Technology, Atlanta, Ga., was elected chairman of the Research and Development Board ad hoc advisory committee for selection of a site for an $11,000,000 Army Quartermaster Corps Research Laboratory.

* * *

ROBERT CALVERT was elected president of the Technical Societies Council of New York, Inc. In recent years Dr. Calvert has been active in the field of technical patents. He is the author of the book "Patent Practice and Management for Inventors and Executives." (For review see page 595 of this issue.)

* * *

DONALD W. PENNOCK, Mem. ASME, factory engineer of Carrier Corporation, was elected president of the American Materials Handling Society. Other officers elected are: HERBERT H. HALL, Mem. ASME, Aluminum Company of America, Pittsburgh, Pa., vice-president; IRVING M. FOOTLIK, Galter Products Company, Chicago, Ill., treasurer, and WENDELL W. PHILLIPS, Eli Lilly and Company, Indianapolis, Ind., secretary.

* * *

JOHN M. HANCOCK, chairman of the board, Lever Brothers, was elected chairman of the American Management Association board for 1950-1951; DON G. MITCHELL, president Sylvania Electric Products, Inc., chairman of the executive committee; and LAWRENCE A. APPLEY, Assoc. ASME, president. HAROLD V. COES, Fellow ASME, and ERWIN H. SCHELL, Mem. ASME, were among the 12 executives elected as new directors of the association. ALVIN E. DODD, Fellow ASME, was re-elected honorary president.

* * *

TITUS G. LeCLAIR, assistant chief electrical engineer, Commonwealth Edison Company of Chicago (Ill.), was elected president of the American Institute of Electrical Engineers.

* * *

FRANK McKINLESS was appointed manager, Detroit office, Engineering Societies Personnel Service, Inc. Colonel McKinless is a graduate of the Colorado School of Mines and served in the Marine Corps in both world wars.

* * *

SIR HARRY R. RICARDO, Hon. Mem. ASME, was elected an honorary member of The Institution of Mechanical Engineers.

Meetings of Other Societies

July 12-14

Engineering Institute of Canada-American Society of Civil Engineers, joint summer convention, Royal York Hotel, Toronto, Ont., Can.

Aug. 14-18

National Association of Power Engineers, Inc., national convention, Hotel Jefferson, St. Louis, Mo.

Aug. 28-31

American Mining Congress, metal mining convention and exposition, Utah State Fair Grounds, Salt Lake City, Utah

Sept. 4-8

American Chemical Society, 118th national meeting, Chicago, Ill.

Sept. 18-22

Instrument Society of America, national instrument conference and exhibit, Municipal Auditorium, Buffalo, N. Y.

(*For ASME Calendar of Coming Events see page 603*)

ASME NEWS

New England Industrial Center to Be Scene of ASME 1950 Fall Meeting

THE 1950 Fall Meeting of The American Society of Mechanical Engineers will be held at the Hotel Sheraton, Worcester, Mass., Sept. 19-21, 1950. Worcester is a city of 200,000 people and over 600 industries. So varied are the products of these industries that Worcester is often referred to as the "City of Diversified Industry."

But Worcester has another claim to distinction. Its mayor, Andrew B. Holmstrom, is an engineer and a member of the ASME. His address of welcome will have a special meaning for engineers. He is a graduate of Worcester Polytechnic Institute, 1917, and vice-president of Norton Company, Worcester's largest manufacturing organization.

Worcester is well known as the home of abrasive products and grinding machinery, precision machine tools, lathes and injection-molding machines, rolling mills, firearms, rugs, looms, leather products, clocks, and many other metal goods, shoes, textiles, steel and wire goods, and machinery.

Well-Known Music Center

Worcester is more than an industrial community. Its famous music festival will celebrate the 88th season this fall. Music lovers from all over the East come each year to hear the world's finest singers and musicians at the Memorial Auditorium.

The Worcester Art Museum and its school, endowed for $6,000,000, is one of the finest for its size in the country. The headquarters of the American Antiquarian Society with its thousands of volumes of historical data is located in Worcester.

John Woodman Higgins, general chairman of the Fall Meeting Committee, and chairman of the Board of Directors of Worcester Pressed Steel Company, is the founder of the Higgins Museum which contains one of the most nearly complete collections of medieval armor in the world.

In addition to Worcester Polytechnic Institute, Worcester is the home of Holy Cross College, Clark University, Assumption College, and Worcester State Teachers College. Worcester Academy, a boys' school for over 100 years, has an international reputation. There are many other educational institutions which prepare students for careers in business, nursing, trades, airline operations, and other fields. Worcester is also an insurance center. Five major companies maintain home offices there.

Many visiting ASME members will be interested in Worcester's city government which is operating for its first term under a council-manager charter. At last fall's election, Mayor Holmstrom received nearly two and a half times the number of first-choice ballots as his nearest contender in a field of 130 candidates (Worcester's municipal voting is by proportional representation) and he was the only candidate to be elected on the first count. As a result of this overwhelming vote, he was chosen mayor by the nine elected councillors according to the rules of the city charter.

Interesting Program for Women

Wives of members are cordially invited to attend the Fall Meeting. A program will be arranged to include many events of interest to women. Tentative plans include visits to the historic Wayside Inn made famous by Longfellow; Sturbridge Village, an authentic replica of an early New England town; Worcester Art Museum; Higgins Museum; and other points of interest.

The committees selected by the Worcester Section for the Fall Meeting are as follows: Andrew B. Holmstrom, honorary chairman; John W. Higgins, general chairman; Raymond H. Tolman, vice-chairman; Robert S. Hahn, Worcester Section chairman; Eric H. Smith, technical events chairman, Leslie J. Hooper, vice-chairman; George W. Motherwell, finance chairman; Philip A. Nims, vice-chairman; Warren S. Snow, plant visitations chairman; Carroll C. Tucker, hotel and registration chairman; Bradley C. Higgins, reception chairman; Philip R. Delphos, entertainment chairman; Charles M. McMahon, printing and signs chairman; and Roger N. Perry, Jr., publicity chairman.

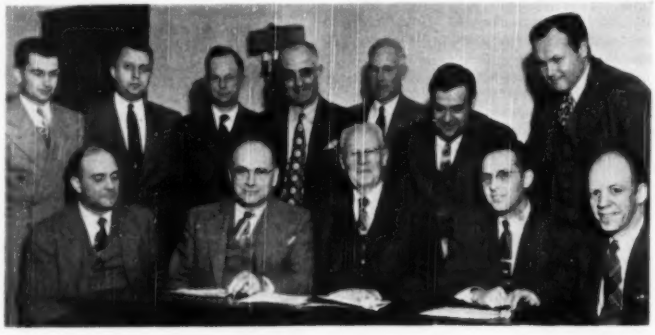
Plans Set for ASME 1950 Petroleum Conference

THE Petroleum Division of The American Society of Mechanical Engineers has chosen cost reduction as the theme of its 1950 Petroleum Mechanical-Engineering Conference to be held at the Roosevelt Hotel, New Orleans, La., Sept. 24-28, 1950. A full three-day program consisting of 18 technical sessions on such subjects as production, transportation, refining, and application of petroleum and its products is planned. In addition there will be a pleasant social program, a sightseeing trip about New Orleans, as well as an all-day inspection of the field operations of the Freeport Sulphur Company.

On the subject of production of petroleum products, the planning committee has arranged for papers on long-stroke and hydraulic pumps, percussion drilling, gas-lift operations, offshore drilling, protection of structures in sea water, and others.

Among the papers dealing with transportation of petroleum products are those discussing damping pressure surges, offshore pipe lines, mechanical sampling of liquid streams, crankcase explosions, and others. Refining papers include such subjects as steam power in refineries, corrosion at high temperatures, stock losses, and others.

The Petroleum Division of the ASME serves mechanical engineers in the petroleum industry by providing a forum in which everyday mechanical-engineering problems on all aspects of production, transportation, refining, and application of crude petroleum and its products are discussed. Chemical-process problems, test codes, and standards for petroleum prod-



ARRANGEMENTS COMMITTEE FOR THE 1950 FALL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS TO BE HELD AT THE HOTEL SHERATON, WORCESTER, MASS., SEPT. 19-21, 1950

(*Front row, left to right:* Philip R. Delphos, George W. Motherwell, John W. Higgins, Raymond H. Tolman, Robert S. Hahn. *Second row, left to right:* Philip A. Nims, Roger N. Perry, Jr., Eric H. Smith, Carroll C. Tucker, Charles M. McMahon, Warren S. Snow, Bradley C. Higgins.)

ucts however, are not considered within the scope of its work.

Its conferences during the past four years at Tulsa, Houston, Amarillo, and Oklahoma City, and its sessions at National ASME meetings, have developed a veritable gold mine of information on petroleum mechanical engineering. Engineers who have not attended any of these meetings may still benefit from the papers discussed through the purchase of bound volumes of the Tulsa and Houston conferences from the ASME Order Department.

Members planning to attend the 1950 conference are urged to make hotel reservations early by writing to Mr. W. J. Verlander, A. M. Lockett & Company, P. O. Box 561, New Orleans, La.

Actions of the ASME Executive Committee

At a Meeting at Headquarters, May 18, 1950

A MEETING of the Executive Committee of the Council was held in the rooms of the Society on May 18, 1950. James D. Cunningham, chairman, presided. In addition to Mr. Cunningham there were present: Forrest Nagler, vice-chairman, Fred S. Blackall, jr., Albert C. Pasini, Ralph A. Sherman, of the Executive Committee; H. E. Whitaker (Finance), H. E. Martin (Organization), E. G. Bailey, and J. M. Todd, past-presidents, A. R. Mumford, vice-president, Edgar J. Kates, assistant treasurer, C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary.

Screw-Thread Meeting in Paris

S. A. Tucker, a member of the Society staff, attended a meeting held in Paris, April 17–20, 1950, representing, on behalf of ASME and SAE, the ASA Sectional Committee B1 on Standardization and Unification of Screw Threads at the meeting of the Working Committee of ISO/TC/1 on Screw Threads. Mr. Tucker presented a brief report which is noted on page 527 of the June issue. The Executive Committee extended a vote of thanks to the Society of Automotive Engineers which had made a contribution toward defraying Mr. Tucker's expenses.

Policy on International Standards

At the conclusion of an extensive discussion in which Mr. Blackall emphasized the obligation of the Society to provide travel funds for attendance at meetings overseas in connection with standards and codes of an international character, the Executive Committee authorized the Secretary "to take such steps as he deems necessary to discuss with representatives of the U. S. Government the question of participation of representatives of government, professional societies, or private industries in international standardization matters."

Registration Policy

On recommendation of Board on Education and Professional Status the Executive Committee adopted the following as the registration policy of the Society:

1 Encourage and co-operate in the registration of professional engineers and approve in principle the Model Law.

2 Suggest that each Section should devote some time in a Section meeting each year to the subject of engineering registration, where, if possible, they would have a member of the State Registration Board address them.

Suggest that each Section appoint a standing committee to be known as the Registration Committee, to co-operate with the State Registration Board and the Section Program Committee in the dissemination of information on registration.

3 The importance of disseminating registration information to student branches is paramount as evidenced by the numerous requests from students desiring well-directed advice. Care must be exercised to provide a competent speaker on this subject to appear before each student branch annually.

Information on registration, including a digest of existing state registration laws should be incorporated in the Student Branch Manual.

4 Offer the facilities of the Society to assist in the revision or modification of registration acts in States requesting such assistance.

Research Agreements

On recommendation of the Research Committee and the Board on Technology two research agreements were approved:

(1) Between the Society and Battelle Memorial Institute covering a study of the suitability of selected commercially available alloys for use in superheaters at steam temperatures in excess of 1200 F.

(2) Between the Society and the Illinois Institute of Technology covering a study of sliding friction at high pressures and elevated temperatures.

Charles T. Main Topic for 1951

On recommendation of the Board on Honors the Executive Committee approved the topic "The ASME and the Young Engineer" for the Charles T. Main 1951 Award.

1950 ASME Spring Meeting

Appropriate resolutions of thanks were adopted by the Executive Committee in connection with the 1950 ASME Spring Meeting, held in Washington, D. C., April 12–14. The Committee also voted its grateful thanks and appreciation to the Old Guard, who had as guests at the 1950 Spring Meeting 12 juniors from 12 sections in Region III, and suggested that attendance of juniors and seniors at the 1950 Semi-Annual Meeting, St. Louis, Mo., be increased by some suitable means.

Canton-Alliance-Massillon Section

Permission was granted to change the status of the Canton-Alliance-Massillon Sub-Section of the Akron-Canton Section to that of a new section to be known as the Canton-Alliance-Massillon Section.

Certificates

A Certificate of Award was granted R. Tom Sawyer, retiring chairman of the Oil and Gas Power Division.

Special certificates were approved for Edward Flad, St. Louis, Mo., and F. W. Olin, East Alton, Ill., who have been members of the Society 59 and 55 years, respectively, to be presented during the Semi-Annual Meeting at St. Louis in June.

Society Emblem

Permission was granted the Milwaukee Public Library to reproduce the ASME emblem on the walls of its science and industry department.

ASME Calendar

of Coming Events

Sept. 18–22
ASME Instruments and Regulators Division Conference, Municipal Auditorium, Buffalo, N. Y.
(*Final date for submitting papers was May 1, 1950*)

Sept. 19–21
ASME Fall Meeting, Hotel Sheraton, Worcester, Mass.
(*Final date for submitting papers was May 1, 1950*)

Sept. 25–28
Petroleum Mechanical Engineering Conference, Hotel Roosevelt, New Orleans, La.
(*Final date for submitting papers was May 1, 1950*)

Oct. 23–25
ASME Fuels Division Conference, Hotel Statler, Cleveland, Ohio
(*Final date for submitting papers was July 1, 1950*)

Nov. 26–Dec. 1
ASME Annual Meeting, Hotel Statler, New York, N. Y.
(*Final date for submitting papers—Aug. 1, 1950*)

April 2–5, 1951
ASME Spring Meeting, Hotel Atlanta Biltmore, Atlanta, Ga.
(*Final date for submitting papers—Dec. 1, 1950*)

April 17–19, 1951
ASME Process Industries Conference, Baltimore, Md.
(*Final date for submitting papers—Dec. 1, 1950*)

June 18–22, 1951
ASME Semi-Annual Meeting, Hotel Royal York, Toronto, Ont., Can.
(*Final date for submitting papers—Feb. 1, 1951*)

(*For Meetings of Other Societies see page 601*)

Appointments

The Executive Committee confirmed the following appointments: ASA Sectional Committee for Deep Well Vertical Pumps, B58, P. H. Brown, chief engineer, Johnston Pump Company, Los Angeles, Calif.; H. W. Iversen, professor, college of engineering, University of California, Berkeley, Calif.; and A. Hollander, professor, California Institute of Technology, Pasadena, Calif.; Research Committee on Furnace Performance Factors, G. W. Bice, engineer, mechanical-engineering department, American Gas and Electric Service Corporation, New York, N. Y.; Research Committee on High-Temperature Steam Generation, S. N. Fiala, chief mechanical engineer, American Gas and Electric Service Corporation, New York, N. Y.; ASA Chemical Industry Correlating Committee, J. D. Mattimore, chief engineer, Product Engineering and Research, Tube Turns, Inc., Louisville, Ky.; and W. A. Miller, supervising engineer, Pressure Chemical Plants Division, Blaw-Knox Company, Pittsburgh, Pa.; Subcommittee on Vessels Under External Pressure, H. L. O'Brien, assistant manager, research and development department, Graver Tank and Manufacturing Company, East Chicago, Ind.; Subgroup on Ferritic Plates and Tubular Products, J. G. Althouse, metallurgical engineer, Lukens Steel Company, Coatesville, Pa.; Washington Award Commission (Western Society of Engineers), B. H. Jennings (two-year term commencing June 1, 1950), professor, Technical Institute, Northwestern University, Evanston, Ill.; Junior Committee, Robert Nelsen, technical engineer, General Electric Company, West Lynn, Mass.; Meetings Committee, W. F. Thompson (to fill unexpired term of J. W. Barker, to Dec., 1951), vice-president and chief engineer, Westcott and Mapes, Inc., New Haven, Conn.; National Management Council, Lillian M. Gilbreth (to fill unexpired term of H. B. Maynard, to Jan., 1951), president, Gilbreth, Inc., Montclair, N. J.; A. M. Perrin (three-year term starting January, 1951), president, National Conveyors Company, Inc., New York, N. Y.; *Alternate:* W. A. MacCrehan, professor, director of ordnance, Gage Laboratory, college of engineering, New York University, New York, N. Y.; and T. A. Marshall, ASME Representative on Board and Executive Committee, senior procedure analyst, Coordination Division, Metropolitan Life Insurance Company, New York, N. Y., *Alternate:* C. E. Davies.

The following presidential appointments were confirmed: G. F. Matthes to Louisiana State University, Mid-Century and Group of Conferences on Higher Education, April 13–14; Charles Concordia, honorary vice-president, to World Power Conference; and Philip Sporn and Charles Concordia to Conference of International des Grands Reseaux Electriques (CIGRE), Paris, June 29-July 8, 1950.

ASME Depositories Are Everywhere

247 in U. S.; 57 Overseas

MORE than 300 libraries in the United States and in countries in other parts of the world are serving as depositories for bound volumes of the Transactions of The American Society of Mechanical Engineers. Every year since 1927 when the ASME depository plan was established, the Society has donated to college and public libraries, publications valued at more than $5000. During the war it was impossible to supply some of the overseas libraries, but distribution is resumed as soon as word is received that the library is in operation.

The distribution of libraries serving as depositories is such that a mechanical engineer would find it difficult to isolate himself from the publications of his Society. No matter where he may work, an ASME depository is sure to be close at hand. There are 247 depositories in the United States and its possessions and 57 in 16 countries in other parts of the world.

In selecting libraries to serve as depositories of Transactions including the *Journal of Applied Mechanics*, the ASME Publications Committee is still guided by the policy established in 1927. This specified that depositories should be located (1) at engineering colleges with ASME student branches; (2) engineering schools without student branches whose libraries had stocked Transactions prior to 1927; (3) selected public libraries in industrial centers; and (4) selected university and engineering-society libraries in countries outside the United States.

The following facts about ASME depositories may be of interest. There is at least one ASME depository in each of the 48 states and in the District of Columbia, Hawaii, and Puerto Rico. New York state has the largest number of depositories with 23, followed by Pennsylvania with 22, and Ohio with 18. Except for California with 13 depositories, Western States do not have as many in each state as the rest of the country—only one, two, or three in each state. The small eastern state of New Jersey has 11 depositories, one more than the largest state, Texas. Of the New England States, Massachusetts has 12, while neighboring states of Maine, Vermont, and New Hampshire have only one each; in fact, 14 states have only one depository.

Libraries in 16 overseas countries including Scotland and Wales are depositories for ASME publications. Great Britain has the greatest number, with 20. There are depositories in three South American countries, five European countries, Australia, India, and South Africa; and on this continent, in Canada and Mexico.

This wide distribution of ASME depositories means that no member should be deprived of easy access to Transactions or the *Journal of Applied Mechanics*. If there is an ASME student branch in his vicinity, he will be sure to find a complete set of ASME Transactions dating back to at least 1927, either in the main college library or in the mechanical-engineering departmental library. The public library of his city, if it is a large industrial city, is probably on the depository list.

For information about the local ASME depository, members need only to inquire of Section officers or the honorary member of the local ASME student branch. The complete list of depositories is published annually in Society Records, which is a section of the bound volume of Transactions. The list also is included in the pamphlet copies of ASME indexes to MECHANICAL ENGINEERING, Transactions, and the *Journal of Applied Mechanics*, which is published annually and is available to members from the Order Department for 10 cents a copy.

Junior Forum

The Elderly Junior

THERE are currently over 3500 members of the Society who are not taking advantage of the grade of membership to which they are qualified. These are the junior members who are over 33 years of age, men who are probably qualified for the grade of full member, but who have neglected to apply for the promotion. On their 33rd birthday, not only did they lose exemption from the $10 promotion fee, but they entered the company of elderly juniors whose professional careers are not receiving the recognition to which they may be entitled. Each year a man remains unnecessarily in the junior grade is a year lost toward the requirement for the Fellow grade, which states that a man must have been a full member for at least 13 years. To a young man of 35 this perhaps means little enough, but consider the situation of a distinguished engineer whose friends recently were informed he could not be elevated to the Fellow grade because he had remained in the junior grade for 27 of his 30 years in the ASME.

Pleasant Purgatory

The junior grade, after all, is a kind of pleasant purgatory or the antechamber to the hall of full membership. It should never be the basis for permanent satisfaction. A junior member is at best a novice who is expected to age in the junior grade until, through experience, he gains the perspective and soundness of judgment called maturity.

Full membership is the hallmark of professional maturity. Employers know the ASME reputation for high membership qualifications. Full membership carries its own prestige, but when it is coupled with youth, the effect is not lost on an engineer's superiors, or on the technicians and craftsmen who work for him, or on any potential employer. These benefits alone should cause a pressure from young men for promotion to the full member grade—especially from elderly juniors and from those to whom the designation of junior is a burden.

In April, 1950, there were 18,429 junior members on the Society's roster. Of these, 10,872 were under 30 years of age and paid an annual dues of $10; 3672 were in the 30 to 33 age bracket and paid $15 dues; and 3885 were the elderly juniors who may be missing the recognition to which age and experience entitle them.

Take Initiative Now

Probably most, if not all, of the 3672 juniors in the 30 to 33 age group are qualified for full membership. They ought to write immediately for application forms and to arrange for the necessary references. Time flies and their 33rd birthday may yet find them in the junior grade.

What does it take to become a member? Any engineering graduate can become a full member after four years in the junior grade, if for three of those four years he was "in a position of responsible charge of engineering work" and "is qualified to direct such work or to carry on important research or design in the field of engineering."

The phrase "responsible charge of engineering work" should not make any junior hesitate, for it is not a specific reference to the function of a vice-president or chief engineer but is intended to cover the whole range of responsible work which a mature engineer may be called upon to assume. This requirement is interpreted justly by the ASME Admissions Committee which, while zealous for the Society's high membership standards, is composed of practical engineers who know industry and the demands it makes upon its engineers.

Are you an elderly junior? Now is the time to apply for promotion to the full member grade.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., in co-operation with the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to all engineers, members or not, and is operated on a non-profit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrant members whose availability notices appear in these columns. Apply by letter, addressed to the key number indicated, and mail to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available at a subscription of $3.50 per quarter or $12 per annum for members, $4.50 per quarter for nonmembers, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	84 East Randolph Street	100 Farnsworth Ave	57 Post Street

MEN AVAILABLE[1]

MECHANICAL ENGINEERING, graduate, 38, registered engineer, bilingual, married. Experience: maintenance, conveyerization, modernization production methods, and tooling, administrative abilities; full knowledge woodworking, furniture finishings. On general superintendent's position, P. Q., Canada. Available immediately. Me-689.

MECHANICAL ENGINEER, 25, locate anywhere, preferably South or Southwest; desires research work on internal-combustion engines, gas turbines, rockets, or ballistics. Experienced in machining and racing engines. Me-723.

DEVELOPMENT ENGINEER, BSME, registered, 29, married. Six years' experience adapting new procedures to production. Experienced in mechanical finishing. Desires plant or production engineering position with opportunities for advancement. Me-724.

MECHANICAL ENGINEER, 23, single, BME, RPI, Sigma Xi. Diversified experience R. R. passenger-car construction, design, and engineering in methods-engineering department. Also experience freight-car maintenance. Held responsible position. Desires position in heavy industry. Will relocate. Me-725.

ENGINEER, 35, MS in CE, Harvard Graduate School of Engineering. Experienced in design and analysis of rail cars, truck trailers, aircraft, miscellaneous structures, artillery, gun tubes, preparation and editing of technical and design reports. Ambitious, resourceful. Registered in Pennsylvania. Desires administrative position. Me-726.

EXECUTIVE ENGINEER qualified as plant manager, superintendent, chief engineer, or staff assistant. Twenty-five years' practical design, manufacturing, and sales experience in the field of automatic machinery, tools, and instruments. Development of new products. Capable organizer and negotiator. College graduate ME, 47. Me-727.

MECHANICAL ENGINEER, 27, BME, January, 1950, married, veteran. Precollege experience, one year sales, two years in industry, also summer work as junior engineer and some drafting. Will consider any office, preferably in air conditioning or as industrial engineer. Will relocate. Me-728.

EXECUTIVE MECHANICAL ENGINEER, 47, with 29 years' experience on tool engineering, processing, production, and manufacturing problems. Cost-minded, co-ordinator of human effort. Adaptable as works manager, master mechanic, chief tool and methods engineer or plant engineer on high-precision aircraft instruments, metal stampings, etc. Me-729.

RECENT GRADUATE, 25, single, veteran. BME, industrial-management courses. Methods and time-study experience. Desires trainee or junior position in production or industrial engineering. Relocate or travel. Me-730.

INDUSTRIAL MECHANICAL ENGINEER, junior, master's degree, qualified in time and motion study, production control, statistical quality and cost control, materials handling, plant layout, etc. Able to travel. Me-731.

MECHANICAL ENGINEER, 41, graduate Purdue. Ten years' experience with manufacturer of small precision instruments, in charge of process planning, special tooling, and development of new products. Me-732.

RECENT GRADUATE, 22, single, BME, University of Florida, desires position with future in manufacturing or production supervision. Managerial experience. No objection to small communities or rural areas. Travel. Me-733.

MECHANICAL ENGINEER, BME, NYU, June, 1950, 31, single. Desires South or Midwest. Pi Tau Sigma. Me-734.

CHIEF ENGINEER, 48, married, with 21 years' experience in centrifugal-pump design. Supervise complete engineering department and sales promotion. Experienced in refinery, chemical, pipe-line, and dredge pumps. Travel. Available within two weeks. Me-735-505-D-6.

MECHANICAL ENGINEER, graduate, executive, 25 years' experience, with successful record. Design, development, plant layout, and production of mechanical equipment or steam specialities. Supervision of construction or plant operation. Prefers Buffalo or Niagara Frontier. Me-736.

MECHANICAL ENGINEER, 36, college graduate, 12 years' experience in production, design, and plant engineering. Desires responsible production-engineering position with company manufacturing metal goods. Me-737.

MECHANICAL ENGINEER, 29, BSME, married, registered, seven years' diversified experience boilers and internal-combustion engines; desires production or service work with internal-combustion engine or automotive industry. Middle Atlantic region. Me-738.

INDUSTRIAL ENGINEER, 43, married, 17 years' experience with wage-incentive, work-simplification, and wage and salary administration programs. Thorough background in time study and job analysis and evaluation. Ten of the 17 years in positions of authority and responsibility. Thirty days' notice required. Prefers Calif. or TEXAS. Me-739-4912-D-15.

MECHANICAL ENGINEER, master's degree, Yale, June, 1950, 24, married, seeks position in research, design, development, or instructing. No location preference. Me-740.

MECHANICAL ENGINEER, 29, married, four years' experience design and development of production methods, tools, automatic machinery, and resistance-welding equipment for fabrication, finishing, and assembling small metal parts. Also one and one-half years' radio-manufacturing experience. Location, immaterial. Me-741.

MECHANICAL ENGINEER, 23, recent graduate, two years' diversified experience. Designed and built model for unique wire-winder feeder

[1] All men listed hold some form of ASME membership.

for college course. Desires position as junior designer, New York City vicinity. Me-742.

POSITIONS AVAILABLE

PROJECT ENGINEER, 30–40, experienced on petroleum and/or gas equipment. Must be able to assume supervision of, and responsibility for, entire section. No recent graduate considered as position entails immediate responsibility. Pa. Y-3429.

MACHINE DESIGNER, 40–50, with at least 10 years' automatic, special machinery, and machine-tool-design experience covering packaging and bottling machinery in drug or cosmetic fields, to design and lay out machinery for drug manufacturer. $5000–$6000. New York metropolitan area. Y-3607.

SALES ENGINEER, 35–40, mechanical graduate, with at least five years' sales experience in process industry calling on large engineering, utility, oil, and chemical firms, to sell combustion and process-industry controls for manufacturers agent. $6000. New York, N. Y. Y-3622.

DESIGN AND DEVELOPMENT ENGINEER with about 15 to 20 years' experience in development and design work for company manufacturing electrical and pneumatic equipment. Administrative experience necessary, to manage an engineering group of about 50 people. $10,000. Mass. Y-3641.

MACHINE DESIGNERS with at least five years' experience on the design of steel mill or product machinery, to design and lay out tube mill, flat rolled, processing, and general steel-mill equipment. Salary open. Ohio. Y-3643.

MECHANICAL ENGINEER with design and construction experience and ten to 15 years' plant-maintenance experience in food-processing industry, to take full charge of maintenance and new construction work in several plants. $8000. South. Y-3645.

ASSISTANT CHIEF ENGINEER with ten to 15 years' experience in the design of heavy belt conveyers, support structures, screens, hoppers, and stacking equipment. Materials handling in manufacturing plant positively will not qualify. $10,000. East. Y-3648.

INSTRUCTOR in mechanical engineering, with at least a bachelor's degree, and some industrial experience, to teach in the field of machine tools and allied subjects. Possibilities for research and other forms of personal and scholastic development. $3250 for nine months. New York State. Y-3649.

INSTRUCTOR OR ASSISTANT PROFESSOR, MS, with teaching and industrial experience, (*a*) to teach machine design, materials engineering, applied mechanics, and laboratory courses; (*b*) to teach general mechanical engineering, including metallurgical processes. $3000–$4500. Midwest. Y-3661-D-5830.

ASSISTANT SUPERINTENDENT, 35–50, mechanical graduate, production experience in the line of automotive accessories and household appliances, to act as assistant superintendent in charge of production. $8000–$10,000. Conn. Y-3665.

PRODUCTION MANAGER, 35–45, experienced in the production of industrial instruments such as flowmeters, temperature and pressure recorders, etc. $6000–$8000. Eastern Pa. Y-3694.

TIME-STUDY ENGINEER, with three to five years' experience in metal-manufacturing industry to establish rates, standardize manufacturing processes for cost systems for manufacturer of garage equipment such as lifts, jacks, etc. Salary about $5000. Tenn. R-6469.

SALES MANAGER, up to 40, sales experience on industrial-furnace sales. Knowledge of refractories. Aggressive personality; able to handle sales force, do contact, sales, and engineering work on industrial furnaces. Travel throughout U. S. 50 per cent of time. Salary and bonus. Headquarters, Ill. R-6472.

FACTORY SUPERINTENDENT, general assembly foreman, mechanical background (production), experienced in fabricating and assembling small electromechanical devices. Salary open. Ill. R-6474(b).

ASSISTANT PLANT ENGINEER, BSEE or ME, 28–35, three years' or more experience in plant engineering, food processing. Knowledge of refrigeration and mechanical equipment. General building maintenance and repairs. Keep building and equipment in good working condition. Will have to do some drafting on the board. Repairs, revamping, or installing new equipment or buildings with general plant and equipment for a meat packer. $4160–$5720. Ill. R-6479.

FORGE SHOP SUPERINTENDENT, to 45, with eight years' or more experience in forge shop. Knowledge of metal flow, die, and maintenance. Time study and labor relations. Supervise in forge shop toolroom, millwrights, and general production. Component parts for automotive and agricultural equipment. Board hammers from 600 to 3000 lb. Battery of 11 Chambersburg hammers for drop-forge shop. Salary open. Wis. R-6490.

ENGINEERS. (*a*) Superintendent for machine shop, fully experienced machining automotive parts and shop operations; able to deal with customer for manufacturing plant employing from 50 to 60. Salary open. (*b*) Foreman and setup man, experienced in all machining phases of automotive parts and cylinder heads. Good knowledge of all machines and operations for a manufacturer employing from 50 to 60. Salary open. Wis. R-6499.

CHIEF ENGINEER, 40–45, graduate preferred, with 10 to 20 years' experience in the practical requirements of building superintendency, powerhouse operation and trades supervision, repairs, and maintenance. Informed about general construction requirements. Supervise 35–40 men in large hospital. Salary open. Ill. R-6508.

PROJECT ENGINEER, BSME, with four or five years' experience with product development, hydraulics. Knowledge of controls. Will do research, design; develop, follow through production, and assist in sales. Water thermostats and mixing valves. Must be able to meet and talk with customers for a manufacturer of valves. $5000–$5500. Ill. R-6518.

PROJECT-PLANT ENGINEER, about 40, mechanical background in food or processing plant. With knowledge of tanks, piping, refrigeration, heat exchange, construction methods, estimating, specifications, installation and modification of major plant equipment, and facilities and construction. Supervisory position for brewery. Ill. Salary open. R-6521.

ASSISTANT TO VICE-PRESIDENT, 35–45, graduate, with minimum of 10 years' industrial experience with emphasis on heating and ventilating; knowledge of heating and ventilating manufacturing helpful; informed about market and sales research. Will assist at responsible levels in field and office on heating and ventilating sales, administration, engineering, and installations for a manufacturer. Must know industry. $7500 plus bonus. Ill. R-6522(a).

Candidates for Membership and Transfer in the ASME

THE application of each of the candidates listed below is to be voted on after July 25, 1950, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

R = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

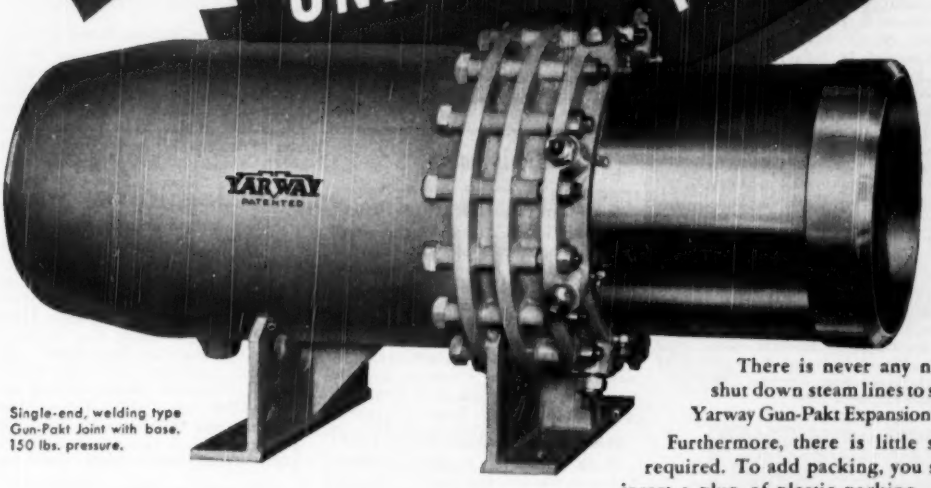
NEW APPLICATIONS

For Member, Associate, or Junior

ALEXANDER, SURAIN, Amritsar, East Punjab, India
BAER, LEONARD, San Francisco, Calif.
BAGLEY, G. J., Bettendorf, Iowa
BALKANY, ERNEST, Cincinnati, Ohio
BEATTIE, W. C., Rockville Center, N. Y. (Rt&T)
BENNETT, J. N., New York, N. Y.
BENVENISTE, GUY, Mexico, D. F., Mexico
BRAINARD, FAY, Portland, Ore.
BRITTON, MASON, JR., Cincinnati, Ohio
BRYDE, WALTER STANLEY, Baltimore, Md.
BUKHSH, MIAN K., Rawal Pindi City, West Punjab, Pakistan
CANEY, ALBERT L., Glen Ellyn, Ill.
CHOWDHURY, NANDA K., Philadelphia, Pa.
CIMET, HERSH, Mexico, D. F., Mexico
COOKE, LEWIS E., JR., Fort Lauderdale, Fla.
CROLL, ARTHUR, Orange, Texas
CRYOR, DONALD PAUL, Lansdowne, Pa.
DEPAOLI, HENRY, Palisade, N. J.
ECKERT, E. R. G., Xenia, Ohio
ELDIN, HAMED KAMAL, Washington, D. C.
ELEK, LUIS, Lomas de Chapultepec, Mexico
ELLIS, GILES M., JR., Port Wentworth, Ga.
EVANS, PALMER D., Drexel Hill, Pa.

(*ASME News continued on page 608*)

THIS EXPANSION JOINT IS SERVICED UNDER FULL STEAM PRESSURE



Single-end, welding type Gun-Pakt Joint with base. 150 lbs. pressure.

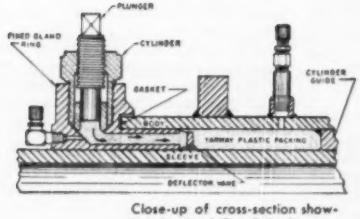
There is never any need to shut down steam lines to service Yarway Gun-Pakt Expansion Joints.

Furthermore, there is little service required. To add packing, you simply insert a plug of plastic packing, turn a wrench, and the job's done! Special Alemite fittings provide for proper lubrication.

Maintenance costs are trifling. One large user reports 65 cents per year per joint. Others claim less than that.

Gun-Pakt Joints are available with single or double-ends, welding or flanged types, in sizes from 2″ to 30″, with traverses from 4″ to 24″, and for pressures to 400 psi.

For the full Gun-Pakt story, write for Yarway Bulletin EJ-1912.



Close-up of cross-section showing detail of Gun-Pakt feature.

YARNALL-WARING COMPANY
108 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY

GUN-PAKT EXPANSION JOINT

EVANS, WALTER R., Kingsville, Texas
EWERT, RICHARD H., Chicago, Ill.
FAROOKHI, MOHD. MUMTAZ, Washington, D. C.
FERRER, M. RODERS, Bayside, N. Y.
FISHER, ARTHUR, Dalton-in-Furness, Lancashire, England
FITZGERALD, ROBERT C., Elkridge, Md.
FLOYD, JOSEPH H., Bellerose, N. Y.
FULLERTON, THOMAS J., Chicago, Ill.
GARCIA, JOSEPH, JR., Norwood, Mass.
GARLAND, EDWARD J., Worcester, Mass.
GAY, C. H., Akron, Ohio
GILL, GEORGE M., Texas City, Texas (Rt & T)
GOALWIN, RICHARD T., Washington, D. C.
GOLDMANN, PHILIPP, New York, N. Y.
HASAN, MUBASHIR, Lahore, West Punjab, Pakistan
HEAD, ROBERT R., Boulder, Colo.
HEBERLING, JOHN R., Newark, N. J.
HOLMAN, FRANCIS ARTHUR, Norwood, Ohio
IRVINE, ROBERT L., Pittsburgh, Pa.
JACOBO, AGREST, Buenos Aires, Argentina
JOHNS, ROBERT ARTHUR, Racine, Wis.
JOHNSON, F. E., JR., Far Hills, N. J.
KALPAKCIOGLU, SERGPS, Watertown, Mass.
KELLEY, SIDNEY G., JR., Sharon, Conn.
KNOBELOCH, HUGH J., Beloit, Wis.
KNOX, CHARLES S., JR., Cedar Rapids, Iowa
KUEHN, FREDERICK WINTON, Conyngham, Pa.
LAGRONE, P. T., E. Pittsburgh, Pa.
LEDGE, RALPH W., Rutherford, N. J.
LEHR, HAROLD D., Elkins Park, Pa. (Rt)
LEONARD, FRANK Q., Chicago, Ill.
LIEBRECHT, PAUL C., New Milford, N. J.
LINDQUIST, T. N., San Francisco, Calif.
MACFARLANE, GEORGE F., Ionia, Mich.
MACGEE, ROY C., JR., West Medford, Mass.
MANDEVILLE, ARTHUR R., Palmyra, N. J.
MATHESON, ROBERT R., Cleveland, Ohio
MCGRAW, E. CLYDE, New York, N. Y.
MCGUIRE, T. W., Washington, D. C.
MCLAIN, BENJAMIN, Tucson, Ariz. (Rt & T)
MILLER, ARDEN T., Mt. Pleasant, Pa.
MISIR, STEPHEN JOSEPH, Stamford, Conn.
MONSON, MARTIN J., Atlanta, Ga.
MORRISSEY, JAMES LOUIS, Chicago, Ill.
MYRON, PAUL, Berea, Ohio
NASH, WILLIAM F., JR., Pasadena, Calif.
NELSON, DONALD WAYNE, Chicago, Ill.
OLSON, ROBERT L., Concord, Calif.
OVERAS, ARTHUR J., E. Chicago, Ind.
PAGE, H. W., New York, N. Y. (Rt & T)
PARANT, NOEL, Astoria, N. Y.
PARKER, GILBERT S., Brooklyn, N. Y.
PELLER, ROBERT C., Brookings, S. Dak.
PIERCE, FRANCINE, New Rochelle, N. Y.
POTTER, CHARLES RICHARD, Arlington, Va.
REARICK, G. H., Alliance, Ohio
REHFELD, ERICH, Sao Paulo, Brazil
REMEC, V., Chicago, Ill.
SHUBSNER, JOHN H., San Francisco, Calif.
SOO, SHAO LEE, Cambridge, Mass.
SPAHR, GUSTAV L., Philadelphia, Pa.
SPETTA, DONALD ALBERT, Bohemia, N. Y.
STEIJE, JOHN F., Chicago, Ill.
STEMLER, WM. H., Freeport, Texas
SULLIVAN, JAMES E., Jackson Heights, N. Y.
TEPLE, LAWRENCE S., Milwaukee, Wis.
TURNER, EUGENE L., Newton, Iowa
WAGNER, GILBERT J., Kansas City, Mo.
WAKERLY, RALPH F., Chicago, Ill.
WATANABE, HOWARD T., Salt Lake City, Utah
WORK, CLAYTON W., Pittsburgh, Pa. (Rt & T)
YENCHO, EDWARD A., Taylor Springs, Ill.
ZIMMERMANN, ALFRED P., Jeannette, Pa.
ZYDNER, PAUL B., Klamath Falls, Ore.

CHANGE IN GRADING

Transfers to Member and Associate

ABBOTT, WARD D., Orchard Park, N. Y.
BIET, CARL E., Cincinnati, Ohio
BURTON, CHARLES A., Metairie, La.
CARLSON, PAUL G., San Diego, Calif.
DIMM, WILLIAM, Bellerose, N. Y.
ELIZONDO, HECTOR R., Habana, Cuba
GRIESHABER, GEORGE W., San Francisco, Calif.
HECKMAN, THOMAS PAUL, Richland, Wash.
HEPPARD, GLENN R., Harrisburg, Pa.
HOLME, THOMAS T., Bethlehem, Pa.
MAYNARD, WILLIAM G., Baltimore, Md.
OAKLEY, HAROLD C., Dansville, N. Y.
OVESTRUD, MELVIN, Minneapolis, Minn.
PAUL, ARTHUR N., Lawrence, Kans.
ROWE, HENRY A., Akron, Ohio
SCANLAND, BOYD, Signal Moutain, Tenn.
SCHRADER, CARL G., Mill Valley, Calif.
SCOTT, ROBERT S., New York, N. Y.
STEPHENS, JAMES O., Swarthmore, Pa.
VESTAL, DONALD M., JR., College Station, Texas
WEBSTER, FRED N., Princeton, Mass.
WERNICK, NATHANIEL K., Brooklyn, N. Y.
WINTER, FREDERICK C., Teaneck, N. J.
WOOD, JOHN B., Bellevue, Pittsburgh, Pa.

Transfers from Student Member to Junior 961

Obituaries

Jean Stuart Chadwick (1916–1950)

JEAN S. CHADWICK, mechanical engineer, formerly technical-data supervisor for service-parts department, Aircooled Motors, Inc., Syracuse, N. Y., died April 4, 1950, at his home in Syracuse, N. Y. Born, Syracuse, N. Y., Nov. 12, 1916. Parents, Frank B. and Kittie S. Chadwick. Education, BSME, Syracuse University, 1939. Jun. ASME, 1939. He served the Society as a member, Executive Committee, Syracuse Section; chairman, Program Committe, 1950. Survived by parents.

Philip Lancaster Clarke (1885–1948)

PHILIP L. CLARKE, engineer, Southern California Gas Co., Los Angeles, Calif., died Dec. 8, 1948, in Glendale, Calif. Born, Durango, Colo., Dec. 4, 1885. Parents, Henry Philip and Frances (Harris) Clarke. Education, BSME, Purdue University, 1907. Married Grace Helen Hollingworth, 1916. Jun. ASME, 1907, Mem. ASME, 1920. Survived by wife and two daughters, Mrs. George H. Merhoff, Burbank, Calif.; and Mrs. Thomas J. Shannon, Van Nuys, Calif.

Oliver Colbert Cromwell (1860–1950)

OLIVER C. CROMWELL, former assistant chief of motive power and equipment, Baltimore and Ohio Railroad, died March 30, 1950. Born, Cumberland, Md., Aug. 29, 1860. Parents, Andrew Jackson and Margaret Ann (Holliday) Cromwell. Education, Maryland Institution. Married Kate W. Fowler, 1885. Mem. ASME, 1914. Survived by his wife, two sons, William A., Springfield, Ohio, and Howard T., Pittsburgh, Pa.; a daughter, Mrs. Maurice G. Heron, Baltimore, Md.; and four brothers, Charles G., Coeur d'Alene, Idaho; Henry C., D. Frank, and Edgar H., Baltimore, Md.

Robert Barnes Dickson (1883–1950)

ROBERT B. DICKSON, president, Kewanee Boiler Corp., Kewanee, Ill., and a director, American Radiator and Standard Sanitary Corp., died at his home in Kewanee, Ill., of a heart ailment, April 9, 1950. Born, Streator, Ill., Jan. 13, 1883. Parents, Gavin and Elizabeth (Logan) Dickson. Education, public schools. Married Ellen E. Kellogg, 1915 (died 1949). Assoc. ASME, 1938. Survived by two children, James and Mrs. Dorothy D. Anderson.

Godfrey Davidson Doig (1890–1950)

GODFREY D. DOIG, operating and maintenance engineer, Cunard-White Star Steamship Co., New York, N. Y., died April 24, 1950. Born, San Francisco, Calif., May 11, 1890. Parents, David Chalmers and Grace (Davidson) Doig. Education, University of California. Married Harriet Ehrich, 1927. Assoc-Mem. ASME, 1927; Mem. ASME, 1935. Survived by wife.

Abram Mayer Feldman (1862–1950?)

ABRAM M. FELDMAN, whose death was recently reported to the Society, was a consulting heating and ventilating engineer. Born, Berdichev, Kiev, Russia, Aug. 7, 1862. Parents, Simon and Menicha (Mermelstein) Feldman. Education, Teachers' Institute, Russia; BSME, University of Pennsylvania, 1891. Naturalized, Chicago, Ill., 1895. Married Ella N. Goldwater, 1912. Mem. ASME, 1900.

Horace Pugh Fry (1873–1950)

HORACE P. FRY, retired 1944, professor of mechanical engineering, University of Pennsylvania, died April 23, 1950, in Hahnemann Hospital, Philadelphia, Pa. Born, Philadelphia, Pa., May 9, 1873. Parents, Horace P. and Sarah (Scholfield) Fry. Education, BSEE, University of Pennsylvania, 1895; ME, 1927. Married Lucretia Mott Gaskill. Author, "Notes on Mechanical Drawing." Mem. ASME, 1920. Survived by wife and three children, Horace P., Jr., Swathmore, Pa.; Mrs. Guido R. Henry, Connellsville, Pa.; and Mrs. Harry G. Stauffer, Drexel Hill, Pa.

William Keen Gale (1900–1950)

WILLIAM K. GALE, mechanical engineer, Otto Construction Co., New York, N. Y., died at the Horace Harding Hospital, Elmhurst, L. I., March 14, 1950. Born, West Chester, Pa., Aug. 14, 1900. Parents, Freeman K. and Jeannette (Briggs) Gale. Education, Rhode Island School of Design; Brown University Extension Courses. Married Ida M. Gills. Mem. ASME, 1944. Survived by wife and son, William K., Jr.; and a sister, Janet Gale, New York, N. Y.

James Albert Gish, Jr. (1883–1949)

JAMES A. GISH, JR., plant manager, Carolina Giant Cement Co., St. George, S. C., died Nov. 9, 1949, at the Dorchester County Hospital, Summerville, S. C. Born, Philadelphia, Pa., April 1, 1883. Parents, James Albert and Hannah M. (Robinson) Gish. Education, public schools and private tutors for advanced studies. Married Edna Louise Fidler, 1938.

(*ASME News continued on page 610*)

MAY WE ASSIST YOU, SIR?

If you're on a merry-go-round about handling air or gas, *R-C dual-ability* can help you.

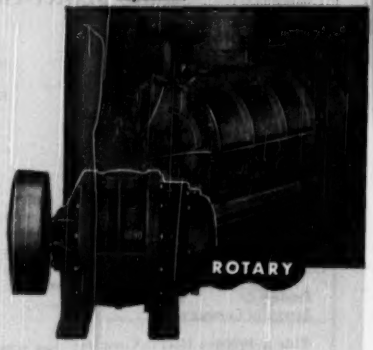
That's been our exclusive job for almost a century. We've developed the most extensive line of blowers, exhausters and gas pumps in the industry, with capacities from 5 cfm to 100,000 cfm.

Then, we're the only builders offering that *dual choice* of both Centrifugal and Rotary Positive equipment. Thus, without bias, we can suggest units that meet most closely the requirements of the work to be done.

So, for new installations or for replacements, look to us for your needs. Alert engineering teams up with modern construction to insure long-time, successful performance of R-C equipment.

ROOTS-CONNERSVILLE BLOWER CORPORATION
507 Michigan Avenue, Connersville, Indiana

Six R-C Multi-Stage Centrifugal Blowers equipped with automatic regulators to provide extremely wide range of operation at various pressures and capacities.



ROOTS-CONNERSVILLE
BLOWER BUILDERS SINCE 1854
ONE OF THE DRESSER INDUSTRIES

DOING ONE THING WELL FOR ALMOST A CENTURY

Assoc-Mem. ASME, 1914; Mem. ASME, 1935. Served as chairman, Anthracite-Lehigh Valley Section, 1942–1943. Survived by wife.

John Wilson Gray (1867–1950)

JOHN W. GRAY, former assistant to the general manager, Newport News Shipbuilding and Dry Dock Co., died April 29, 1950, at his home in Ardmore, Pa. Born, Ironton, Ohio, Sept. 11, 1867. Parents, George N. and Eliza Ann (Humphreys) Gray. Education, Drexel Institute, mechanic arts, 1895. Married Rebecca M. Cadwallader, 1904; children, Jane E. and Charles C. Jun. ASME, 1895; Mem. ASME, 1926.

Robert Stanley Haight (1876–1950)

ROBERT S. HAIGHT, marine surveyor, consulting engineer, and vessel appraiser, New York, N. Y., died April 3, 1950, at the Long Island College Hospital, Brooklyn, N. Y. Born, Westchester, N. Y., Oct. 4, 1876. Parents, Louis H. and Cornelia Haight. Education, ME, Stevens Institute of Technology, 1899. Mem. ASME, 1939. Survived by wife, Edith Stuart Haight, and a brother, Louis H. Haight.

Frank Rogers Hassler (1896–1950)

FRANK R. HASSLER, consulting engineer, St. Louis, Mo., died Jan. 31, 1950. Born, Chicago, Ill., Dec. 3, 1896. Parents, Frank Power and Julia (Rogers) Hassler. Education, BSME, Massachusetts Institute of Technology, 1923. Married Mildred A. Stocking, 1930; son, Frank Lyman. Jun. ASME, 1924; Assoc. ASME, 1927; Mem. ASME, 1935.

Robert Sayre Kent (1864–1950)

ROBERT S. KENT, consulting engineer, president, Robert Sayre Kent, Inc., died Feb. 28, 1950, at his home in Brooklyn, N. Y. Born, Gwynedd, Pa., Sept. 24, 1864. Parents, Rodolphus and Elizabeth (Lyon) Kent. Education, CE, Polytechnic College of the State of Pennsylvania, 1885. Married Jessie Pettit Smith, 1891; children, Rodolphus, Elizabeth Wister, and Katharine Vaughn. Mem. ASME, 1901; Fellow ASME, 1942.

Alphonse Ilya Lipetz (1881–1950)

ALPHONSE I. LIPETZ, retired chief consulting engineer in charge of research, American Locomotive Co., Schenectady, N. Y., also retired nonresident professor of engineering, Purdue University, died April 11, 1950, at the Columbia-Presbyterian Medical Center, New York, N. Y. Born, Lodz, Poland (Russia), Dec. 9, 1881. Parents, Ilya and Bertha Lipetz. Education, ME, Polytechnic Institute, Warsaw, Poland, 1902; also studied at Kiev, Russia, and Munich, Germany. Naturalized, Saratoga Supreme Court, Jan. 19, 1931. Married Basilia Karp, 1910. Melville Medalist, 1938. Mem. ASME, 1919; Fellow ASME, 1938. He wrote many books and articles on locomotive research and held several patents in the locomotive industry. Survived by wife, Dr. Basilia Lipetz; a daughter, Mrs. John Jacob Niles; a sister, Dr. Florentine Karp; and two grandsons.

Thomas Lee Brent Lyster (1878–1950?)

THOMAS L. B. LYSTER, whose death was recently reported to the Society, was chief engineer, Hooker Electrochemical Co., Niagara Falls, N. Y. Born, Detroit, Mich., Sept. 21, 1878. Parents, Henry F. and Winifred L. (Brent) Lyster. Education, BSEE, University of Michigan, 1901; MME, Cornell University, 1903. Mem. ASME, 1915.

Robert MacArthur (1868–1950)

ROBERT MACARTHUR, house-heating engineer, New Haven Gas Light Co., New Haven, Conn., died Jan. 25, 1950. Born, New Haven, Conn., Dec. 31, 1868. Parents, Robert and Jane (McIlwraith) MacArthur. Education, ordinary home schools. Married Margaret Y. Kellock, 1896 (died 1926). Assoc. ASME, 1904. Survived by three children, Mrs. Harold S. Warren, Montreal, P. Q., Can.; Robert K., and Gordon A., New Haven, Conn.

Gerald I. H. Perry (1905–1949)

GERALD I. H. PERRY, engineer, machinery and equipment buyer, R. R. Donnelley and Sons, Co., Chicago, Ill., died in Elgin, Ill., Dec. 30, 1949. Born, Scales Mound, Ill., July 9, 1905. Parents, Otis G. and Augusta V. Perry. Education, BSME, University of Illinois, 1932. Married Dorothy Jack Howard, 1947. Mem. ASME, 1943. Survived by wife.

George William Ramsey (1878–1950)

GEORGE RAMSEY, patent attorney, senior partner, Ramsey, Chisholm, and Hilder, New York, N. Y., died of a heart attack in Hampton, Conn., Feb. 11, 1950. Born, Morning Sun, Preble County, Ohio, Oct. 31, 1878. Parents, John M. and Susan (Reeves) Ramsey. Education, Ohio Northern University; Bradley Polytechnic Institute; LLB, George Washington University, 1908. Married Edith A. Corey, 1911. Author, "Patents." Chairman, Secretary of Commerce's Advisory Committee on Patent Laws. Mem. ASME, 1916. Survived by wife.

Ridgway Lloyd Rowley (1883–1950)

RIDGWAY L. ROWLEY, director, charge of engineering and fire-insurance department, Johnson and Higgins of California, San Francisco, Calif., died March 24, 1950. Born, San Francisco, Calif., Aug. 30, 1883. Parents, Brainard Nathan and Mary E. (Gallagher) Rowley. Education, BS, University of California, 1907. Married B. Perle Strite, 1909; children, Nathan Densmore and Orpha Eleanor. Jun. ASME, 1910; Assoc-Mem. ASME, 1916; Mem. ASME, 1922.

Arthur Jackson West (1867–1950)

ARTHUR J. WEST, mechanical engineer, died in Monrovia, Calif., Jan. 25, 1950. Born, Milwaukee, Wis., March 25, 1867. Parents, Hubbell and Helen M. (Roberts) West. Education, BME, University of Wisconsin, 1887. Married Alice Florence Tourtellot, 1900. Mem. ASME, 1902; Fellow ASME, 1937. Served the Society as vice-president, 1907–1909; Special Committee on Power Tests, 1912–1914. Survived by wife.

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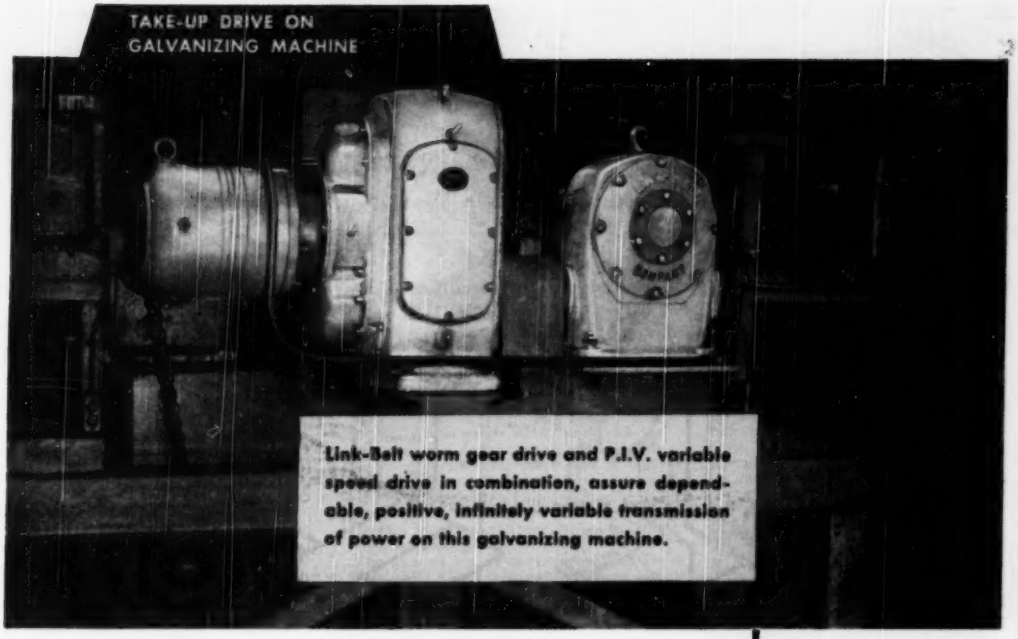
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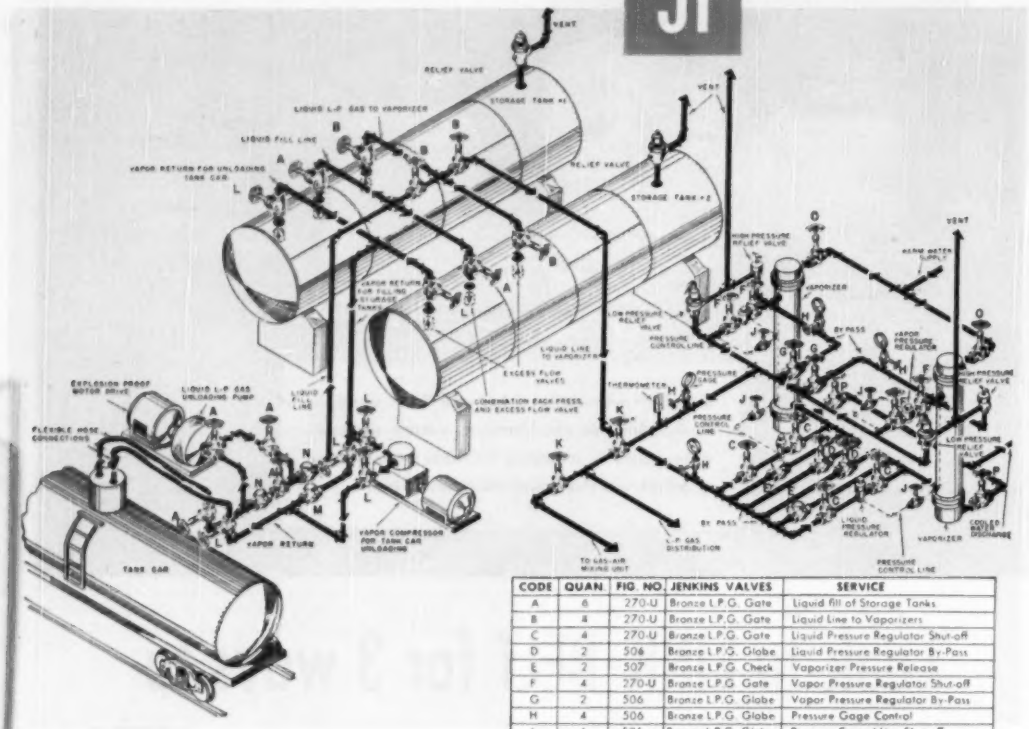
JENKINS PRACTICAL PIPING LAYOUTS 51



CODE	QUAN.	FIG. NO.	JENKINS VALVES	SERVICE
A	6	270-U	Bronze L.P.G. Gate	Liquid fill of Storage Tanks
B	4	270-U	Bronze L.P.G. Gate	Liquid Line to Vaporizers
C	4	270-U	Bronze L.P.G. Gate	Liquid Pressure Regulator Shut-off
D	2	506	Bronze L.P.G. Globe	Liquid Pressure Regulator By-Pass
E	2	507	Bronze L.P.G. Check	Vaporizer Pressure Release
F	4	270-U	Bronze L.P.G. Gate	Vapor Pressure Regulator Shut-off
G	2	506	Bronze L.P.G. Globe	Vapor Pressure Regulator By-Pass
H	4	506	Bronze L.P.G. Globe	Pressure Gage Control
J	4	506	Bronze L.P.G. Globe	Pressure Control Line Shut-off
K	2	270-U	Bronze L.P.G. Gate	Distribution System Shut-off
L	6	270-U	Bronze L.P.G. Gate	Vapor Return for Tank Car
M	1	507	Bronze L.P.G. Check	Prevent Vapor Backflow
N	2	507	Bronze L.P.G. Check	Prevent Liquid Backflow
O	2	47	Bronze Gate	Warm Water Supply
P	2	106-A	Bronze Globe	Cool Water Discharge

How to plan a
STORAGE AND VAPORIZER HOOKUP FOR LIQUEFIED PETROLEUM GAS

PETROLEUM GAS, (propane, butane, etc.) liquefied at atmospheric temperatures by moderate pressures, is shipped by tank car to local storage plants. Diagram shows piping and equipment used in vaporizing and storing these gases.

THE LIQUEFIED GAS is unloaded into storage tanks with the use of liquid pump and vapor compressor. The compressor draws vapor from the tank and returns it to the tank car at a slightly higher pressure, forcing out the remaining liquid. This passes through a regulating valve, to the vaporizer where steam or hot water heating converts it to vapor.

THIS GASEOUS FUEL is then piped through a pressure regulator which assures a constant pressure, and on to the gas distribution system or gas-air mix unit. Duplicate vaporizers provide continuous service in case of breakdown. Safety relief valves are vented to the atmosphere. Check valve on vaporizer inlet acts as a relief valve when vaporizer pressure exceeds that of tank.

Consultation with accredited piping engineers and contractors is recommended when planning major piping installations.

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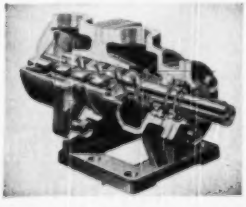
• NEW EQUIPMENT

New Temperature and Pressure Relief Valve

A. W. Cash Valve Mfg. Co., Decatur 60, Ill., announce a completely new valve. The new valve, called "Tempo," is available in several different types and specifications. It is a completely automatic reseating temperature and pressure relief valve with patented features which include a bellows assembly that is entirely up and out of the water in order to forestall liming.

De Laval Introduces New Low Cost Imo Pump

The new De Laval-IMO Series A313A pump is designed for pumping petroleum products and other light or viscous fluids in volumes to 85 gpm against pressures up to 150 psi, as required for rotary and steam atomizing oil burners, oil transfer, lubrication, hydraulic systems and similar service.



This new pump has been designed especially for economical, standardized quantity production. Its reduced cost extends distinct advantages of the IMO principle to a great variety of applications requiring a reliable, quiet, pulsation-free, trouble-free, high speed pump.

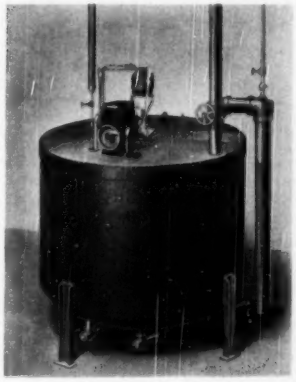
Like all other IMO pumps, the A313A is extremely simple. There are only three working parts—a power rotor and a pair of sealing or idler rotors which mesh with the power rotor in such a manner that liquid is conveyed continuously from inlet to outlet. There's nothing to get out of order or require adjustment. This De Laval-IMO can be direct-connected to electric motors, turbines or other high speed drivers without reduction gearing, belts or chains.

Because of its compact design, the De Laval-IMO A313A requires little space, and the fact that it can be direct-connected to its driver also is a space-saving feature. All parts are interchangeable. The mechanical seal requires no attention. The pump can be mounted in any desired position. Suction can be located at top, bottom, horizontal left or horizontal right.

For additional information, write to De Laval Steam Turbine Co., Trenton 2, N. J.

Data Sheet Available on New Portable Bagging Scale

The Richardson Scale Co., Clifton, N. J., has just made available a data sheet on their new Model E-50 Portable Automatic Bagging Scale for mash feed, pellets and similar materials.



The new Portable Scale is designed to serve a row of bins, and is completely dustproof. A flexible, dust-tight bin connection allows the heavy-duty scale to be positioned under a bin easily and quickly. The scale operator makes all necessary adjustments from the floor level, simply by pulling a chain.

Capacity of the E-50 Portable Automatic Scale is 1 to 4 cu. ft.; rate of discharge, from 10 to 15 per minute. The scale is gravity fed and all mechanisms are easily accessible. An agitator is included in the inlet chute to handle sluggish materials. Four single-flange roller bearing wheels at the base of the scale frame permit it to run along a track under supply bins.

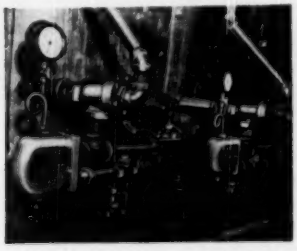
The data sheet on this new Portable Automatic Bagging Scale includes a dimensional working drawing, detailed photographs, and complete mechanical and electrical specifications. Write to the Richardson Scale Co., Clifton, N. J., for product data sheet No. 4916.

Weighing a Huge Steel Casting

Weighing a huge 35-ton steel casting by means of resistance wire strain gages simplified the job for The Baldwin Locomotive Works, Philadelphia. The gages are bonded to short vertical columns incorporated in three load cells of 50,000 lb. capacity each, which were developed for accurate weighing of all kinds. The casting is a semi-rotor to be shipped to a hydro-electric plant in Canada.

Increased Output for Steam-Heated Process Equipment

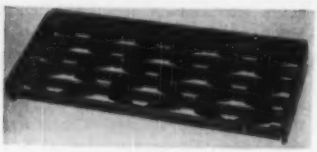
The New Era Dyeing & Finishing Co. of Paterson, N. J. uses a dryer having 12 horizontal heater batteries thru which recirculated air is drawn.



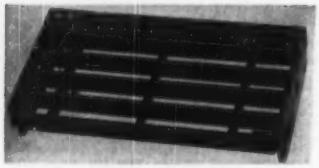
This dryer, originally fitted with 12 bucket type steam traps, is now equipped with 12 Sarco Steam Circulation Systems. The New Era Co. reports: "The air temperature in the 12 horizontal heater batteries has increased from 240° to 290°F, with a reduction of steam pressure from 125 to 90 psi. The dyed materials are now uniformly dried in less time, labor costs are lower, and steam consumption is reduced."

Continued on Page 42

You Need Not
Watch Your Step!
on Stairways of
IRVING "VIZABLEDG" TREADS
With The Distinct Nosing
SAFE CLEAN DRY
DURABLE FIREPROOF
LIGHT STRONG RIGID



Riveted type with grating nosing.



Press-locked type with perforated plate nosing.
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The New Sarco Steam Circulating System accelerates the flow of steam and condensate in the steam spaces of platen presses and horizontal tubular heating surfaces.

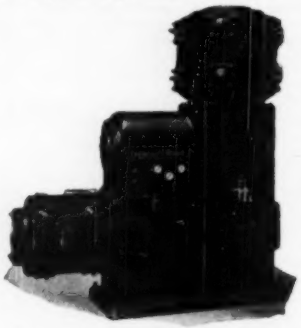
In this type of surface the flow of condensate to the steam trap is usually very sluggish, resulting in slow heat transfer and therefore poor efficiency, for which the steam trap is not responsible.

The Sarco Circulating System consists of a Sarco Float Trap and a Sarco Circulator. This Sarco Circulator is an Injector which uses the uncondensed steam to induce turbulence in the flow of condensate, thus improving the heat transfer and speeding up production with a saving of steam.

Technical bulletin No. 4 contains full information and many easy-to-read diagrams. Sarco Co., Inc., Empire State Bldg., New York 1, N. Y.

New Idea in Compressor Design

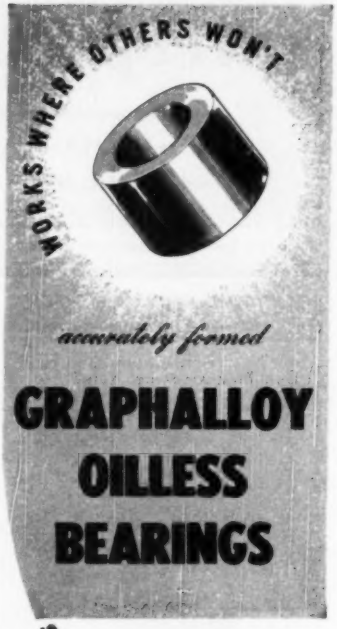
A "New Look" and a new idea in air-compressor design has been incorporated in a new line of modern, packaged-type, heavy-duty electric-driven compressors announced by Ingersoll-Rand. Sizes range from 125 to 350 hp for continuous full-load service and two-stage compression to 80–125 psi discharge pressures. The manufacturer stresses simplicity of design, operation, and maintenance, as well as operating economy and compactness.



Designated as the XLE, this completely new L design embodies a single vertical low-pressure compressor cylinder, a horizontal high-pressure cylinder, and a synchronous motor mounted directly on the crankshaft. It requires only a very small foundation, and is engineered full of new ideas from the inside out.

One innovation is "Pipeless, Thru-Frame Air Flow." Air enters and leaves the compressor through main air connections on the frame, instead of on cylinders, and is led to and from both cylinders and intercooler through large passages within the frame itself. There is no interstage piping nor cylinder strain due to air piping. The intercooler is of a packaged design requiring only 1/4 the space of conventional coolers and fits entirely within the same frame. As a result, the compressor becomes a streamlined, sturdy, and well-ribbed structure that makes the XLE radically different in appearance, extra strong and rigid, easy to install, and easy to keep clean.

Counterflow, tube-and-finned construction of the intercooler is said to give excellent cooling with very little pressure loss and a small quantity of water. It is made of all-copper alloy throughout. Although the compressor valves are of the well-known I-R Channel-Valve type, they are of a new design said to be developed specially for



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GRAPHITE METALLIZING CORPORATION
1058 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

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high efficiency and long life under XLE service conditions.

All bearings in the XLE are full-floating and rotate freely both on the bearing journal and within the rod or bearing housing. Main and crankpin bearings are of aluminum alloy. Combined with pressure lubrication in a sealed, dust-tight crankcase that need not be opened for bearing adjustment, this construction is said to result in cool-running bearings, long trouble-free service, and less maintenance.

The high efficiency, assembled shipment, low-cost installation and relocation, and the heavy-duty construction claimed for the XLE, mean that it is the ideal compressor for factories, railroad shops, mines, powerhouses, and large construction jobs. It is particularly suitable wherever skid-mounting, factory floor, or ground conditions require a well-balanced machine.

For additional information write Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y. or any of its branch offices located throughout the world.

New Silicone Insulated A-C Welder Announced by G. E.

A new silicone-insulated, portable, a-c welder known as the 6WK20H series has been announced by the Welding Divisions of General Electric's Apparatus Department. The 6WK20H series are part of the only standard a-c welder line commercially available incorporating silicone insulation. A high margin of safety and operating dependability is provided by this insulation since it is unaffected by high temperatures and is water repellent.

Compact construction—12 inches by 17 inches in cross section, and 23 inches in height—permits its utilization of underbench and balcony space not available to larger welding units. Practically averaging one-half pound per ampere of maximum output the 6WK20H weighs 154 pounds and has a current range from 30 to 250 amps, and accommodates electrodes from $^1/_{16}$ to $^5/_{16}$ inch diameter. Due to the compactness and balanced design a man can readily lift it and put it in the trunk of his car for transporting.

Instant arc striking without any manual adjustment is provided by "Hot Start" automatic control. The correct amount of boost is always furnished for any specific current setting. The ampere range is

Continued on Page 44

BIDDLE

NUMBER 2 OF A SERIES

Instrument News

JAMES G. BIDDLE CO., 1316 ARCH ST.
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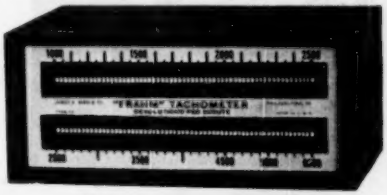
ELECTRICAL TESTING • SPEED MEASURING INSTRUMENTS • LABORATORY & SCIENTIFIC EQUIPMENT

EXTRA WIDE RANGE FRAHM TACHOMETERS® INTEREST TURBINE ENGINEERS



Two rows of 61 reeds each, cover three different speeds; (1) the critical speed of the machine; (2) the running speed; and (3) the double frequency.

For starting up new turbine generators and for trouble shooting vibration difficulties, users of this instrument consider it superior to any other speed measuring device.

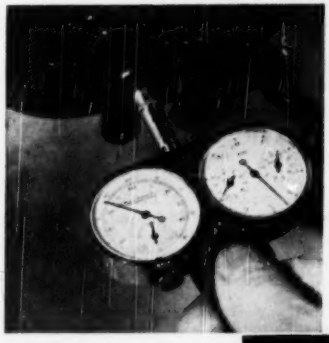
The instrument illustrated has 122 reeds covering a continuous range from 1000 to 6000 rpm. The interval between adjacent reeds is 25 rpm from 1000 to 2500 rpm; 50 rpm from 2500 to 5000, and 100 rpm from 5000 to 6000 rpm.

We invite your correspondence regarding special problems in the measurement of speed and rate of vibration, in which the Frahm resonant reed principle may prove helpful. For an interesting description of these instruments and the many variations of ranges available, send for Bulletin 31-M.

UNIQUE INSTRUMENT INTEGRATES SPEED AND TIME

Eliminates "Human Element" of Error

The Tachoscope is rather remarkable for what it will do in the measurement of speed. It is a speed-counter and stop watch combined in such a way as to eliminate the usual error in starting and stopping. The simple pressing of a lever starts the watch and counter at the same instant. After a suitable time—say 30 seconds to a minute or more—press the same lever to stop both mechanisms. Divide the indicated number of revolutions by the elapsed time (in minutes) and the answer is the average rpm for the time of the test. The instrument is not intended to indicate rpm or fpm directly, as do indicating hand tachometers and speed indicators.



The elimination of error at starting and stopping plus the length of time it may be operated, make the Tachoscope a high precision instrument. Many use it as a standard for other speed measuring instruments. Naturally, the longer operating time results in higher accuracy of the calculated result.

The Tachoscope can be used on many types of machines for speeds up to 20,000 rpm. The high-grade stop watch can be used independently.

SEND FOR BULLETIN 35-M
Includes Handy Selection Chart

If you don't have a copy of this bulletin which includes a handy selection chart, send for Bulletin 35-M. We will mail it to you promptly. Thousands of copies of this helpful and interesting bulletin on Speed Measuring Instruments have been requested since its publication. Did you get your copy?

Solves heat control problem that defeated other thermostats

Appliance-Type THERMOSWITCH* unit

Thermoswitch* unit successfully regulates home pasteurizer

1 gal. pasteurizer. Note THERMOSWITCH* unit

When the Waters-Conley Company first started making home pasteurizers, they ran into a major difficulty.

They wanted a thermostat that combined low cost with reliable, sensitive temperature control and ruggedness. Yet ordinary thermostats could not meet these conditions. It took the Fenwal Appliance THERMOSWITCH* unit to solve the problem successfully.

This unique, long-lasting thermostat dependably maintains the constant temperature so important to proper pasteurization of milk. But it is surprisingly low priced.

The Fenwal THERMOSWITCH* unit operates on a unique principle. Its activating element is the single-metal case that expands or contracts with temperature changes, making or breaking the electrical contacts enclosed within it.

You, too, can benefit from its performance. It is used in a wide variety of applications throughout industry. For ways in which the complete line of Fenwal THERMOSWITCH* units can help you, **MAIL COUPON TODAY**

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SENSITIVE. . . . but only to heat

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☐ Ventilation	☐ Motors	☐ Cabinets
☐ Quick freezing	☐ Transformers	☐ Liquid baths

OTHER (Please fill in your special requirements)

.....

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covered by three overlapping current ranges which permit precise current control. Thus with "Hot Start" control and overlapping current ranges, lower operating costs are assured because idling current is reduced to a minimum and more efficient use of electric power is accomplished.

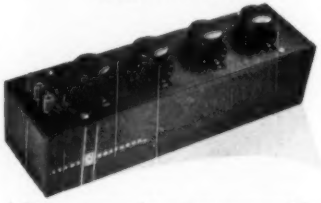
The standard Model 6WK20H contains a primary switch and is designed for operation on 220 volts. Models are available for operation on 440 volts with or without power factor capacitors.

The automatic "hot start" control—composed of a hermetically sealed gas filled time delay magnetic switch and a wound resistor—causes a surge of increased current to flow through the welding leads. This surge is present only during the critical starting period, and its degree is considerably higher at very low "hard to start" currents than at higher "easier to start" current settings. Automatic reduction of boost at higher current settings avoids drawing current surges from the power line. It is of simple construction to give trouble free operation for it has no delicate relays, rectifiers, or fuses, and is not affected by dust.

Coils of the welder are impregnated with Class H insulation, characterized by the use of asbestos, glass, and mica, impregnated by synthetic high temperature resisting resins known as silicones. Silicones are unique in retaining mechanical and electrical strength at temperatures where ordinary varnishes char and disintegrate. The welder windings have been rated at the conservative temperature rise of 130C to provide long life. Coils are well ventilated to operate at uniform temperatures without hot spots. Temperature does not creep up, but coils run as cool in the afternoon as in the morning. The welder is not limited to 4-hour operation to avoid overheating.

A primary switch to interrupt both sides of the line is of double pole construction and provides a convenient means of turning the welder on and off. Insulated tapered plug connectors are provided for easy connection of the welding leads and quick selection of desired current range.

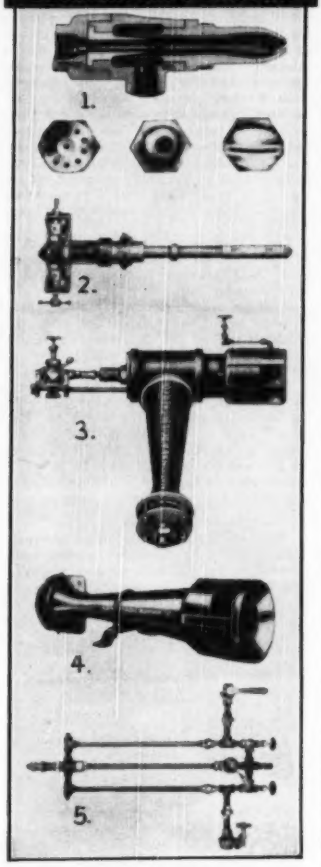
New Leeds & Northrup A-C Resistance Boxes Have Silver Switches, Low "Zero Resistance"



New resistance boxes just announced by Leeds & Northrup Co. are designed for use as moderate-precision, adjustable standards for d-c and for a-c-resistance measurements up to medium frequencies. Principal feature of the boxes is an entirely new type of rotary switch having exceptionally low and stable contact resistance, obtained through the use of solid silver switch contacts and silver alloy multiple-leaf brushes. Zero or contact resistance is less than 0.002 ohm per decade and changes less than 0.0005 ohm per decade on accelerated life tests. Switches are totally enclosed to keep out dust, and are equipped with adjustable indexing action.

Terminals are knurled, all-metal, plated for low contact resistance. They accommodate banana plugs, spade or spring clips, or

THE *RIGHT* OIL BURNER OR GAS BURNER *FOR YOUR JOB*



TYPE "S-A"

1. (For use where steam is available) *atomizes thoroughly* and *burns completely*, the lowest and cheapest grades of fuel oil and tar, requiring only low oil pressure and temperatures. Send for Bulletin No. 21.

TYPE "S-A-L"

2. (Large capacity burner similar to TYPE "S-A-R") is adaptable in combination with powdered coal burners in large boilers. Send for Bulletin No. 24.

COMBINATION GAS AND OIL BURNER

3. —the "AIROCOOL" Gas Burner in combination with a TYPE "S-A-R" Oil Burner. Send for "Airocool" brochure.

"AIROCOOL" GAS BURNER

4. (Of venturi type) assures low turndown without burnback. Send for "Airocool" brochure.

TYPE "S-A-D"

5. (Refuse Oil Burner) burns acids or caustic oils, sludges, asphalts, tank bottoms, polymer oils, heavy petrolatum, organic oil residuums, waste cutting oils, sulphite pulp liquors, etc. Send for Bulletin No. 21.

NATIONAL AIROIL BURNER CO., INC.

Main Offices and Factory:
1239 E. SEDGLEY AVE., PHILADELPHIA 34, PA.
Southwestern Division: 2512 South Boulevard
Houston 6, Texas

• Keep Informed

oare wire of any size—give positive electrical contact even on fine gage wire without danger of shearing.

Housed in attractive grey enameled metal cases, the resistance boxes are thoroughly shielded. Current rating for each decade is engraved on the nameplate.

Limit of error is ±(0.05 per cent + 0.005 ohm). 4-dial model has a range of 11,110 ohms in 1-ohm steps. 5-dial models cover 11,111 ohms in 0.1 ohm steps or 111,110 ohms in 1-ohm steps. Time constant at 50 kc for usual range of dial settings is less than 0.05 microsecond.

Further information available from Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Yale & Towne Announces New "Yard King" Fork Truck

A new pneumatic-tired fork lift gas truck for use over rough uneven terrain at the plant has been announced by the Philadelphia Division of The Yale & Towne Manufacturing Co.

Named the "Yard King," the new Yale industrial truck is designed to bring the cost saving advantages of Yale & Towne's mechanized handling methods to building-supply yards, construction projects, airports, freight docks, and other outside storage and shipping areas.

Previously, Yale trucks have been built primarily for use on average floors, but the addition of oversized pneumatic tires in combination with other exclusive features help the "Yard King" overcome high maintenance costs, operator fatigue, and other natural enemies commonly found in outdoor applications where the "going" is likely to be rough and dusty.

Easy steering, for example, is provided by an inclined king pin which also protects the steering gear against road shock caused by uneven terrain.

Cadmium plating on all undercarriage operating and steering connections reduces damage from atmospheric rust and corrosion.

An extra-large radiator and cooling system help prevent overheating, and an unusually low center of gravity provides great stability.

A smooth acting, Chrysler fluid-drive and clutch assembly minimizes wear on the clutch, ordinarily an item of high maintenance cost which is particularly trouble-

Continued on Page 48

Ledeen
CYLINDERS
IMPROVE THE JOB

Their Uses, Features, Selection, Mounting, and Application

Discussed in New Bulletin 500

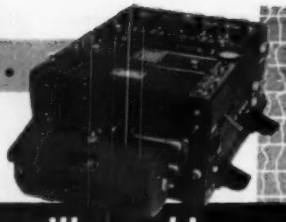
Write for your copy Today!

Wherever you have to push or pull, lift or lower, press or squeeze, tilt or turn, open or close.

Ledeen cylinders are good cylinders!

Ledeen Mfg. Co.
1600 San Pedro
Los Angeles 15, Calif.

All you need...



for complete oscillographic recording

The S-8 Oscillograph, long the standard of oscillographic recording, has been improved to meet the expanding demands of modern research. The NEW Type S-8 Oscillograph has all the inherent capabilities you need to record rapidly changing phenomena such as vibration and dynamic strain.

A few of the newest features are:

QUICK-CHANGE TRANSMISSION—16 record speeds over range of 120:1

FULL RESILIENT MOUNTING makes possible use of super-sensitive galvanometers

CHART TRAVEL INDICATOR provides continuous indication of chart motion

NEW GALVANOMETER STAGE takes all Hathaway galvanometers for recording milliamperes, microamperes, and watts.

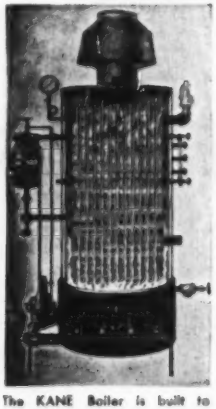
NEW RECORD-LENGTH CONTROL and NUMBERING SYSTEM for long, trouble-free service

All the other valuable features characteristic of the S-8 are retained. Investigate the NEW Type S-8 and its 170 types of galvanometers.

Write for Bulletin 28 1-K

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

WILL YOU HAVE **Steam** FOR PROCESSING THIS SUMMER?



The KANE Boiler is built to A.S.M.E. specifications, in sizes to 30 H.P.

Would you like to shut down your central steam system this summer? . . . there is still time to make some saving by doing so. Act now to insure an independent, *dependable* source of Summer Steam for your processes—we would suggest . . .

the Kane Boiler Package

Each KANE BOILER PACKAGE is carefully considered by us as an "individual" job—from the customer's requirements to the finished unit. And each BOILER PACKAGE is a compact, self-contained steam source that includes: the correctly sized KANE Automatic Gas-Fired Boiler complete with gas burner and controls to maintain required steam pressure; and an M-K-O Automatic Boiler Feed system designed to return condensate and supply make-up water as required for highest operating efficiency.

Engineered Steam at its best with four decades of experience at your disposal—so, send your steam problem to us for study and recommendation.

ENGINEERED STEAM AT ITS BEST

MEARS·KANE·OFELDT INC.

1903-1915 EAST HAGERT STREET, PHILADELPHIA 25, PA.

FOUR DECADES OF AUTOMATIC GAS-FIRED BOILER MANUFACTURING EXPERIENCE

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some in outdoor fork truck operation. In the "Yard King," starting slip takes place in the fluid coupling rather than in the clutch. Operators are less fatigued thanks to the fluid drive because the starts and stops are smoother and the necessity for changing gears is reduced by more than half.

Other engineering features of the new truck include easy-to-operate automotive type controls, fully articulated rear axles, a hypoid (automotive design) drive at the rear axle, and an hydraulically operated lift and tilt. The frame of the truck is of all-welded construction particularly adaptable for heavy yard work.

The "Yard King" tilting fork truck is available in four sizes that have maximum load lifting capacities ranging from 4,000 to 8,000 pounds.

With an overall collapsed mast-height of 85", the new Yale truck attains a stacking height of 118" to 124" depending on the load capacity of the truck. Other lifts for specialized requirements are also available.

A governor controls the speed of the truck to 13 m.p.h., with or without load. For further information on the new Yale "Yard King" write to The Yale & Towne Manufacturing Co., Roosevelt Blvd., Philadelphia 15, Pa., and ask for Bulletins 5124-28, stating maximum load capacity in which you are interested.

Abart Brings Out New Line of Right Angle Gearmotors

Long and authoritative specialization in speed reduction makes the announcement of a new line of Abart Gearmotors one of exceptional interest. Abart Gear & Machine Co. is now manufacturing gearmotors of right angle type single-phase and three-phase models at its plant, 4837—36 W. 16th St., Chicago 50, Ill.

Motors are of heavy duty type, NEMA rated. The entire Abart unit is rated with extreme conservatism—designed for manufacture on latest most accurate high production, with economy in price and long trouble-free performance.

Standard speeds and ratios are as follows: (Other speeds and specials are available on application). Horsepower 1/6 to 5; ratios 5¼:1 to 100:1; output speeds from 17.5 rpm to 302 rpm. Special voltages, cycles, etc., are furnished on order. These gear motors are remarkably compact. Mounting is one single surface. Units can be mounted in any position. Torques are all taken by semi steel gear case. Gears are of nickel bronze. Worms are integral with shaft hardened and precision-ground. Ball bearings are perfectly spaced and neoprene sealed. Shafts are of special tough alloy steel (180,000 to 320,000 tensile), ground. Insulation is long-life baked varnish. Enclosures drip-proof, totally enclosed, or fan-cooled, optional. Brakes are optional. Durable housing is semi-steel precision machined, for lasting strength and resistance to dirt, grit and corrosion.

A bulletin giving sizes, ratings and prices on single-phase and three-phase models will

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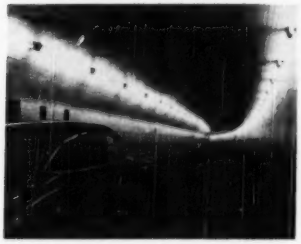
be sent gratis on request on your company's letterhead, to Abart Gear & Machine Co. Ask for Bulletin B250.

The name Abart is recognized as standard on speed reducers for 1/40 to 417 hp., and small gears of any gear material in practically every field of use. Years of engineering experience in the widest range of problems, and a complete and most modernly equipped plant, provide every facility for quality products of greatest dependability.

G-E Equipment in Brooklyn-Battery Tunnel

The longest continuous lighting installation in the world, in which four ribbons of fluorescent light extend almost two miles, was turned on officially for the first time May 25 at the public opening of the Brooklyn-Battery Tunnel.

Designed by New York City's Triborough Bridge and Tunnel Authority in collaboration with engineers of the General Electric Co., the unique lighting system is part of the extensive electric equipment supplied by G.E. for the 9,117-foot tunnel, the second longest underwater tunnel in the world. Other items furnished by G.E. are power distribution equipment, lighting components, switchboards and controls, wire and cable and associated apparatus.



The installation includes eight 1000-kva transformers and six distribution switchboards, located at buildings in Manhattan, Brooklyn, and Governors Island. The switchboards control 53 ventilating fan drives, 36 feeder and bus tie breakers, tunnel and plaza lighting circuits, service feeders, and pumping and auxiliary circuits.

By far the outstanding feature of the electrical "nerve system" of the $80,000,000 tunnel, the lighting installation includes a total of 5,776 individual lamps housed in clear Pyrex "pipes" near the top of the side walls of the twin tubes. Sixteen control cubicles and saturable reactors regulate the intensity of the lights, and astronomical clocks turn on a higher intensity in the portal sections of the tunnel during daylight hours. Thus, driving at normal traffic speed (40 mph in the tunnel), drivers can make a gradual visual adjustment between daylight and tunnel light.

Twenty-four lighting circuits, three running in each direction on both sides of both tubes of the tunnel, supply electricity to the lamps. According to engineers, the system is laid out so that loss of any part of the power supply—including complete loss at one end of the tunnel—will not leave any section of the underwater passage in darkness. There are almost 3,000 fluorescent lighting ballasts in the series circuit, the engineers said, and light meters along the catwalks continuously register the light intensity in the tunnel.

Passing beneath the East River, the new tunnel is the first new link in 41 years between lower Manhattan and Brooklyn. Ground was broken for its construction by the late president Franklin D. Roosevelt on

Continued on Page 48

METAL PLANT
owner estimates savings of $7690 per year with Pangborn Dust Control.

ASBESTOS PRODUCER
reports profit of $20 a day with Pangborn Dust Control.

FOOD PROCESSOR
writes Pangborn Dust Control saves him $3048 per year.

CARBON PRODUCER
reports $1471 yearly profit with Pangborn Dust Control.

CHEMICAL MFGR.
states Pangborn Dust Control saves him $14,859 a year.

FEED MILLER
reports approximately $50 saved each day with Pangborn Dust Control.

WOOD FABRICATOR
estimates $875 saved every year with Pangborn Dust Control.

REFRACTORY
executive reports savings of $4318 per year with Pangborn Dust Control.

RUBBER PLANT
owner reports $100 profit each month with Pangborn Dust Control.

CHARCOAL MFGR.
estimates yearly saving of $13,900 with Pangborn Dust Control.

WHICH DUST PROBLEM BOTHERS YOU ?

READ HOW PANGBORN DUST CONTROL STOPS DUST PROBLEMS LIKE THESE— *at a profit!*

As these authentic cases from Pangborn's files show, Pangborn Dust Control stops dust at a profit! Even where dust can't be sold or re-used, Pangborn users report impressive savings from $1200 to $7000 and more a year.

And where dust is valuable (made up of products or raw materials), annual savings of $12,000, $15,000 or $14,000 a year are not uncommon for Pangborn installations.

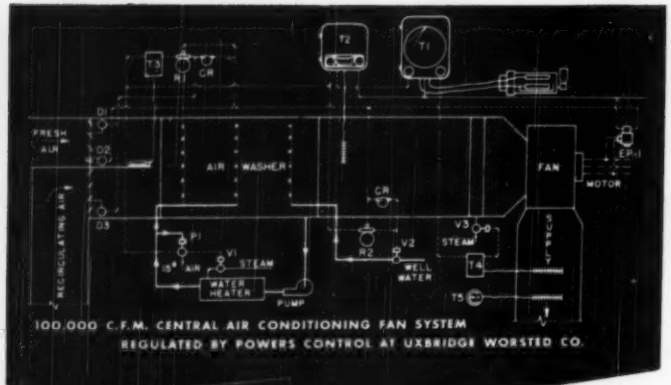
FIND OUT HOW MUCH YOU CAN SAVE! A Pangborn Dust Survey costs nothing—but will show you how you can *turn the dust in your plant* into cash savings. For details, write the PANGBORN CORPORATION, 289 Pangborn Blvd., Hagerstown, Maryland.

Look to Pangborn for the latest developments in Dust Control and Blast Cleaning Equipment.

STOP the DUST HOG from stealing profits with

Pangborn

DUST CONTROL



100,000 C.F.M. CENTRAL AIR CONDITIONING FAN SYSTEM
REGULATED BY POWERS CONTROL AT UXBRIDGE WORSTED CO.

POWERS

AIR CONDITIONING CONTROL
with year 'round accuracy of 1°F. plus or minus regulates over 300,000 C.F.M. at—
UXBRIDGE WORSTED CO.

(T-1) POWERS WET AND DRY BULB RECORDING-CONTROLLING PSYCHROMETERS at Uxbridge Worsted Mill regulate—

One	100,000	C.F.M.	fan system
"	80,000	"	"
"	12,000	"	"
Two	60,000	"	"

(T-2) POWERS INDICATING SUB-MASTER DEWPOINT REGULATORS automatically control the air washers

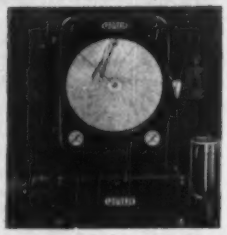
POWERS dampers, valves, relays and other devices are used with T-1 and T-2 to obtain the accurate control mentioned above.

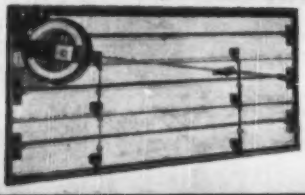
20 to 30% Increase in Efficiency—claimed for modern air conditioning installed in carding, spinning, winding, weaving and sewing departments in Uxbridge, Mass., Mill. Dry bulb temperature of 78° F. and Wet bulb at 68° F.—accurately maintained at all times by POWERS control—helps produce a better product at lower cost.

For Better Air Conditioning Control and valuable aid in selecting the right equipment for your requirements contact our nearest office: CHICAGO 14, ILL., 2751 Greenview Ave.—NEW YORK 1°, N. Y., 231 E. 46th St.—LOS ANGELES 5, CAL., 1808 W. 8th St. Offices in over 50 cities—See your phone book. (ACU)

A FEW OF THE MANY DIFFERENT TYPES OF POWERS CONTROLS

Above: T-2 Powers Series 100 Sub-master Dewpoint Indicating Regulator.
At Right: Powers Series 100 Wet and Dry Bulb Recording-Controlling Psychrometer.
Below: D-1-2-3 Powers Louvre Damper.





V-1-2-3 Powers Diaphragm Valve

Above: T-3-4 Powers Type K Remote Bulb Thermostat.
Below: T-5 Powers Remote Bulb Dial Indicating Thermometer.

THE POWERS REGULATOR CO.
OFFICES IN 50 CITIES • SEE YOUR PHONE BOOK
Over 55 Years of Temperature and Humidity Control

• Keep Informed

October 28, 1940, and it is expected to handle about 16,000,000 vehicles a year when capacity is reached. The nation's longest submarine highway, the Brooklyn-Battery Tunnel is second in the world only to the Mersey River Tunnel at Liverpool, which runs 11,254 feet, excluding approaches.

All power for the tunnel, its approaches, and associated services is supplied through six G-E switchgear units, two each in Manhattan, Brooklyn, and the Governors Island Ventilating Building. Besides the necessary ventilating and lighting power, electricity is furnished for traffic signals, alarms, pumps, and building facilities such as elevators lights, vacuum cleaners, machine shop, etc.

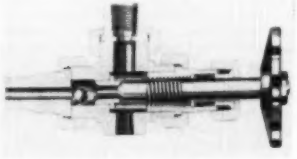
It was explained that pumps are needed to keep the tunnel free from water accumulation caused by speepage, washing, and condensation within the tunnel, and by rain and snow at the portals.

G.E. also furnished photoelectric overheight indicators for the tunnel approaches. These devices sound an alarm and turn the traffic signals red when a light beam is interrupted by a vehicle that is too tall to pass safetly through the tube, it was said.

More than 1700 miles of wire link the components of the tunnel's electrical system with each other and with the main control board in the Service Building in Brooklyn. This board is the central "brain" of the system and permits control of ventilation in order to keep the carbon monoxide concentration in the tunnel below a predetermined level. Carbon monoxide detectors register the gas concentration throughout the tubes and the measurements are continuously relayed to the control board so the flow of vehicles or speed of ventilation can be regulated accordingly. The ventilation is sufficient to keep the tunnel safe even in the event of an accident in one of the tubes. In case of fire or other emergency, signals are immediately picked up on the control board in Brooklyn so that the necessary traffic and ventilation control can be taken care of and emergency squads alerted.

Double Union Gage Valves

Three new Jerguson Double Union Gage Valves have been announced by the Jerguson Gage & Valve Co., Sommerville 45, Mass., in a move to make available a wide variety of double union models to meet the needs and choice of engineers with varying application problems.



The distinctive design and construction of the new Jerguson Double Union Gage Valves, with union connection to both the gage and the tank or vessel, makes it possible to turn the gage in any desired angle or quickly and easily remove it without removing the valves or draining the liquid from the vessel. The gage can be taken to the work bench for easier servicing or replacement of gaskets or glasses. With the valves in "closed" position, the gage may be removed by merely undoing the union nuts on the gage side, without draining or relieving the pressure of the vessel. Both removal and replacement of the gage can be accomplished in much less time. The whole group of Jerguson Double Union Gage

• Keep Informed

Valves also lend themselves to making substantial cost savings in applications as standard angle globe valves.

New valves of this type which have been added to the popular No. 64 Valve, to complete the line, include two Offset Valves, No. 66-U and No. 46-U, and a steam-jacketed globe type valve, the No. 93-U.

The two offset valves are designed with a body which has gage and vent or drain connections, offset $^{7}/_{8}$" so the interior of the flat glass gage may be cleaned without removal of the gage. These two models are also used on side connected gages to gain maximum visibility between fixed centers.

The No. 93-U Valve, being a steam jacketed globe valve type, eliminates the necessity of costly steam tracing, and is available either with or without a stainless steel ball check safety shutoff.

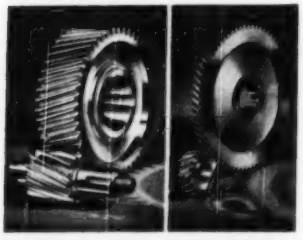
Features of all four Jerguson Double Union Gage Valves include plain or quick closing, stainless steel trim, and interchangeable unions, nuts and tail-pieces. All are available with tailpieces $^{1}/_{2}$" or $^{3}/_{4}$" male, or $^{1}/_{4}$" female; and all are available in various metals to withstand corrosive or other conditions. All have regrindable seats with the exception of the 46-U which is of a lower price construction.

New detailed Data Units are available, identified as Literature on Jerguson Double Union Gage Valves, from Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

New Gear Engineering Service Offered by Foote Bros.

Foote Bros. Gear & Machine Corp., Chicago, is offering industry a new service in standardized gear sets. Duti-Rated gears, produced by this company, have been pre-engineered for life expectancy and horsepower capacity. Data on these standardized gear sets have been prepared in convenient tabular form, making the procedure of selecting gears comparable to selecting antifriction bearings.

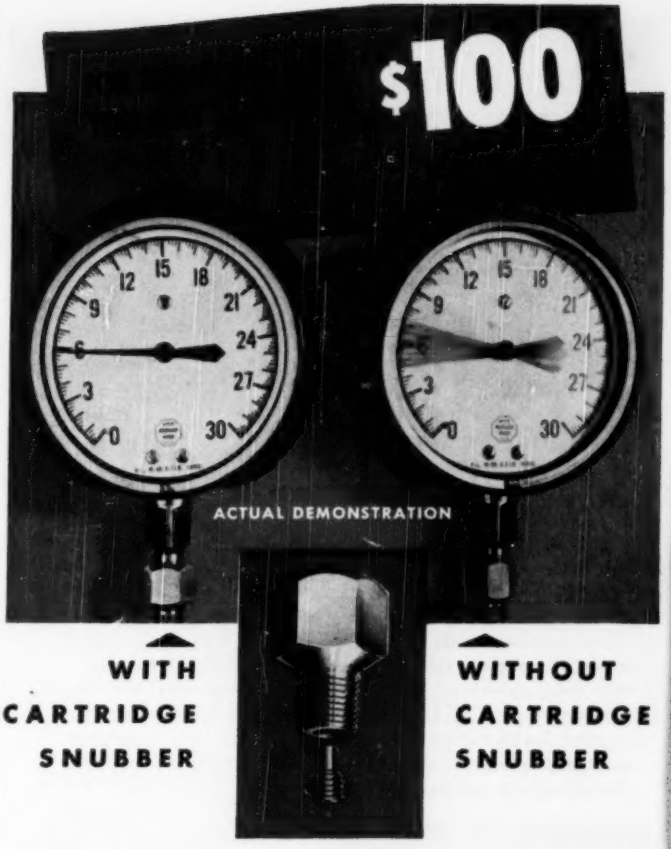
The manufacturer states that Duti-Rated gears save much of the engineering costs formerly required in designing special gears. By selecting gears from standardized tables it is unnecessary to allow for extra strength and capacity as a precautionary measure. Also, by selecting standardized gears, much quicker delivery is possible.



Foote Bros., large producer of extremely accurate gears for aircraft use, states that it has adapted these techniques to the production of Duti-Rated gears. Such high quality precision gears, they claim, have never before been commercially available. By combining file hard tooth surfaces with ductile cores, it is possible to produce gears having load carrying capacity and wear life comparable to commercial gearing but permitting a great reduction in size and weight.

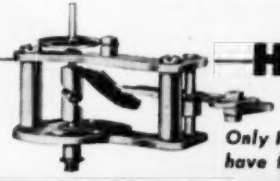
For example, the manufacturer states that a Duti-Rated gear set having a center distance of 2.625 inches and weighing 4.8 pounds will meet the same loading and life

Continued on Page 50



• Why wreck gages needlessly? When pressure pulsations are so rapid that the gage pointer vibrates excessively, a HELICOID Cartridge Snubber is needed. This is the most simple and effective of all pressure pulsation dampeners. It is threaded into the gage socket for only 54¢. It may save you up to $100.00 a year in gage replacement expense!

For severe pulsation services, order your Helicoid gages with snubber cartridges in the socket. Or, order complete snubbers separately. Specify for water, air or oil; ¼" or ½"; bronze or stainless steel.



HELICOID

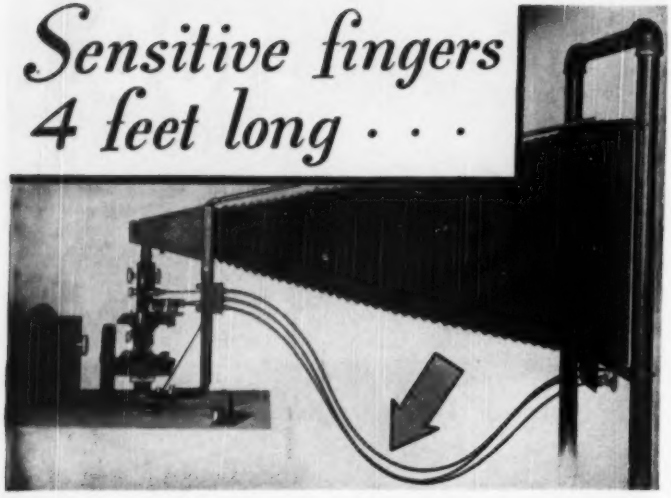
ACCO

Only Helicoid Pressure Gages have the Helicoid Movement

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE COMPANY, INC.
Bridgeport 2, Connecticut

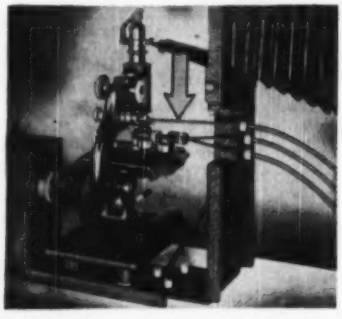
TRADE MARK

Sensitive fingers 4 feet long . . .



FOCUS A MICROSCOPE

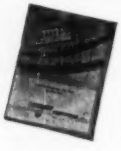
They're S.S.WHITE remote control type flexible shafts. As the illustrations show, they connect the microscope's three focusing knobs to control knobs 4 feet away. And they fully satisfy the application's need for close, sensitive manipulation. They would do this whether the distance was 4 feet or 40—because S.S.WHITE remote control flexible shafts are engineered and built expressly to provide smooth, sensitive remote control. They have the necessary characteristics for the job.



Close-up shows how flexible shafts are connected to microscope of the Microprojector shown above. The enlarged image of the microscope's field is thrown on a translucent screen on the right end. From a position in front of this screen the operator focuses and centers the image.

Photos courtesy Mine Safety Appliances Co., Pittsburgh, Pa.

ASK FOR . . BULLETIN 4501



It gives engineering data about S.S.WHITE flexible shafts and tells how to select and apply them. Write for a copy today.

S. S. White MAKES IT RIGHT

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO. — DEPT. L — 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AND ACCESSORIES
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

One of America's AAAA Industrial Enterprises

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requirements of an ordinary commercial gear having a center distance of 6.30 inches and weighing 41 pounds. Such space and weight savings are said to be typical of the entire Duti-Rated line.

Because of the savings in size and weight, and despite the greater accuracy and higher quality of Duti-Rated gears, the manufacturer claims that important savings in cost are possible. These savings range from 10% to 50% as compared with ordinary commercial gears.

It is also claimed that Duti-Rated gearing gives higher mechanical efficiency, and that the extreme accuracy of this gearing means quiet operation.

It is stated that the compact design of Duti-Rated gears also represents savings in weight and size on the housing in which they are enclosed, which further reduce the cost of the machines on which they are used.

These gears are in quantity production and are available in approximately 200 combinations with ratios from 1.5 to 9.3 and center distances from 2.7 to 15.5 inches. Horsepower capacities range from fractional up to several hundred horsepower. Gearing is available in four basic pinion constructions and two gear types for maximum flexibility in application.

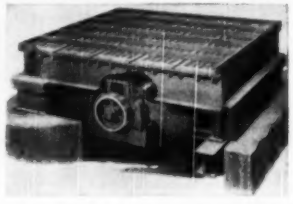
Suggested applications of this gearing cover practically the entire field of parallel shaft power transmission within the size range offered. The use of this gearing is of particular importance in new design where size is controlled by the gear set capacity rather than by externally imposed limitations and where minimum cost must be achieved. A second highly important use is in the replacement of parallel shaft gearing of softer steel construction where gear failure has been a problem for a given application.

Foote Bros. Gear & Machine Corp., 4545 South Western Blvd., Chicago 9, Ill., has prepared a complete bulletin giving full information on Duti-Rated gears with selection, dimensions and rating tables, which is available to any manufacturer interested in incorporating gears in his product. Write for Bulletin DRA—which will be sent without obligation.

Link-Belt Heavy-Duty "CA" Foundry Shakeout Announced

Link-Belt Co. announces that, in order to provide faster, better, cleaner separation of sand and castings from flasks and molds, it has developed a new line of Heavy-Duty "CA" Foundry Shakeouts.

One of these shakeouts was shown in operation in the Link-Belt exhibit at the Foundry Show in Cleveland, May 8–12, for the first time.



These new Shakeouts are available in standardized sizes ranging from Model CA46 with load capacity of 8,000 lbs. to Model CA610 of 30,000 lbs. load capacity. Other sizes can also be furnished.

By eliminating the laborious, time-consuming process of emptying flasks manually, these rugged full-floating foundry shakeouts (1) permit continuous straight-line operation

• Keep Informed

for greater output; (2) make possible centralized dust control for improved plant conditions; (3) hasten reduction of sand lumps and temperatures for quicker recovery of sand; (4) eliminate flask damage; and (5) simplify reclamation of reinforcing rods, gaggers and sprues.

The vibrating deck is accessible from all four sides. There are no projecting parts to catch on clothing or be easily damaged by heavy flasks or castings.

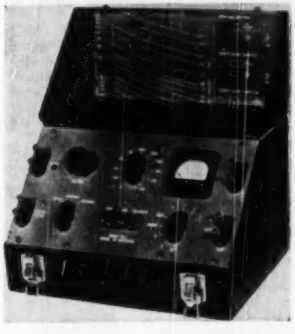
Ready accessibility to operating parts makes inspection, lubrication and servicing fast and simple; assuring economical operation and maintenance.

Decks on non-discharging types are set horizontal. On discharging types they are sloped so that castings move to discharge end by the combined action of gravity pull and vibratory motion. Either type can be furnished with side cowls and hoods for confining dust.

A copy of new 4-page illustrated Link-Belt Folder No. 2338, giving further information, including sizes, dimensions, weight and horsepower, will be furnished gratis to any interested reader, upon request.

Dynamic Strain Amplifier

A new type, portable strain amplifier, designed for use with any standard cathode ray oscilloscope to measure almost any mechanical reaction detected by SR-4 bonded resistance wire strain gages, is announced by The Baldwin Locomotive Works, Philadelphia 42, Pa.

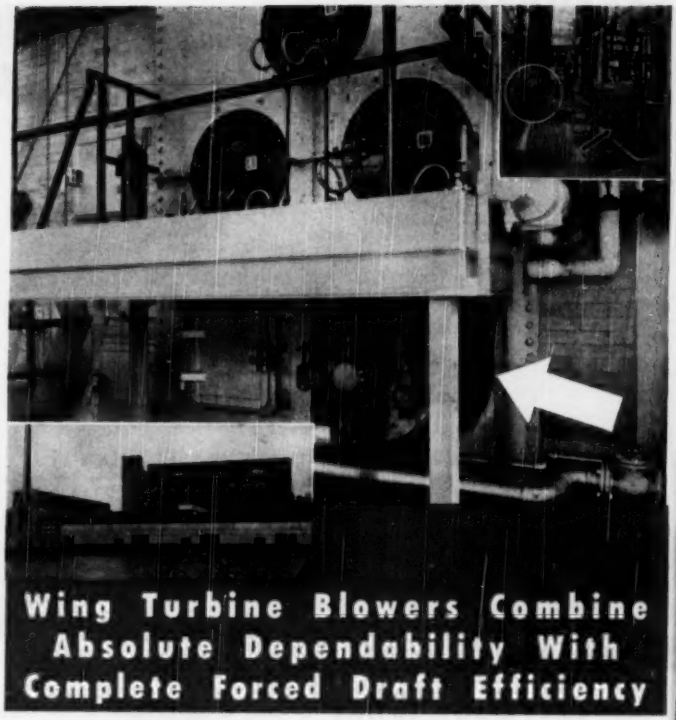


This instrument, known as the Model BA-1, may be used for load measurements, stress analysis and function analysis during operation of equipment to show amplitude, frequency and wave form of sharp transients, steady state oscillations, static loads or their combinations. Displacement, acceleration, vibration, damping, timing, weight, and pressure can be seen and measured during operation of machines or mechanical devices. Data may be recorded by means of either special high speed cameras or an ordinary still camera without shutter.

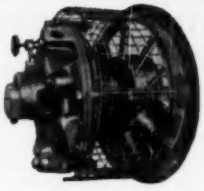
The BA-1 is a complete package of bridge elements, signal chopper, calibration system, amplifier and power supply. Internal bridge elements handle either single-gage dynamic measurements or two-gage static and dynamic measurements. A switch clears the circuit for use of an entirely external bridge system connecting into the amplifier input.

The signal chopper is a unique feature which indicates the static unbalance of the bridge by shorting the bridge output at 100 cps. without affecting calibration. Static and low frequency components of the signal are shown with the signal chopper on and

Continued on Page 53



Wing Turbine Blowers Combine Absolute Dependability With Complete Forced Draft Efficiency

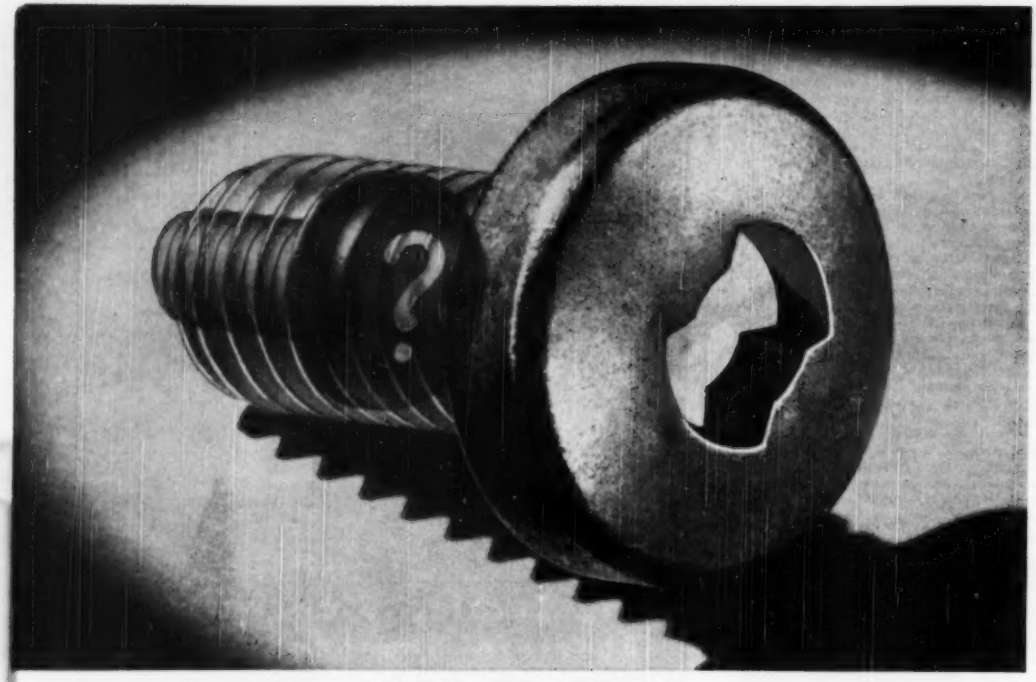


Shown above is a typical Wing Turbine Blower installation serving one of the world's largest coffee packing plants. Note that the engineer (upper right photo) is able to talk on the telephone a few feet away from the Wing Turbine Blower—ample proof of its quiet operation. Write today for Bulletin

In addition to these prime requisites, Wing Turbine Blowers have many extra money saving features including minimum cost of operation, simple, rugged, and compact construction, and because little or no duct work is required, no time and expense is required for engineering layout. Where plants can make use of the low pressure steam from the Wing Turbine Blower for such uses as feed water heating, process work, or space heating, the forced draft is obtained at negligible cost.

L. J. Wing Mfg. Co. 156 Vreeland Mills Road, Linden, N. J.
Canadian Factory: Montreal

Wing
AXIAL FLOW
BLOWERS



Over What Other Screws Does CLUTCH HEAD STEP-UP PRODUCTION *50%?*

Over All Other Type Screws...

RECESSED HEADS AS WELL AS SLOTTEDS

TYPE "A" ASSEMBLY BIT

COMMON SCREWDRIVER

CLUTCH HEAD's modern design meets today's competitive selling problem of how to "Produce More For Less" . . . by effecting time and cost-savings that quicken production steps all the way down the assembly line. On the basis of experience resulting from changeover from other types of recessed head screws, here is how these users score CLUTCH HEAD supremacy:

High visibility of the clutch recess inspires operator confidence for unhesitating faster driving, while dead-center entry with the Center Pivot Column prevents driver canting. Straight driving is automatic . . . hence no burred or chewed-up heads.

Absence of "ride-out," due to CLUTCH HEAD's non-tapered driving engagement, checks out hazard of driver skidding. Freedom from end pressure makes driving effortless, safer and smoother for a stepped-up tempo.

The Lock-On to check out fumble spots . . . screw and bit locking as a unit to permit one-handed reaching and driving from any angle.

The unequalled durability of the Type "A" Bit with a record of driving 214,000 screws non-stop . . . plus the economy of its repeatable reconditioning in a simple 60-second operation.

The importance of CLUTCH HEAD'S basic design for common screwdriver operation . . . to simplify adjustments and cure field service "headaches."

These exclusive CLUTCH HEAD *advantages are illustrated and detailed in this new Brochure.*

Your copy will come to you by mail on request with mention of the types and sizes of screws in which you are interested.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

high frequencies are observed with the chopper off.

Calibration can be checked readily at any time by using the chopper to connect a calibration-resistor across the active gage intermittently. Ten built-in precision resistors from 10,000 to 10,000,000 ohms cover the range of gages and signal amplitudes normally used. Binding posts provide for an external calibration resistor.

The amplifier reproduces all frequencies between flat 5 to 20,000 cps., the full range that is likely to be encountered in practical engineering work. Ample gain is provided to operate any standard cathode ray oscilloscope at the maximum usable sensitivity. Noise level is minimized by use of battery power, shock mounting and proper selection of components.

Micro-inches in strain can be determined by using graphed curves in the cover of the instrument. This is a calibration means for predetermining the amount of deflection in the oscilloscope beam from zero to several thousand micro-inches strain. This is advantageous in dynamic work because the speed of the trace deflection is too fast to read and interpret as it occurs.

The instrument is contained in a case approximately 12 × 10 × 8 inches and weighs 22 pounds with batteries.

P-D Stacks "Can Take It"!

On Friday, May 19th, at approximately 7:30 P. M., almost 500 tons of munitions blew up in Raritan Bay, South Amboy, N. J.

Just 400 yards away, the 56,000 KW plant of the Jersey Central Power and Light Co. took the full concussion from the blast. Because of the proximity of the plant to the point of explosion, concern was felt for the stacks, exposed to the full force of the concussion. There seemed little hope that they would survive in condition to service the boilers.

As the main photograph shows, the steel stacks, manufactured by Prat-Daniel Corp. of East Port Chester, Conn. as an integrated Fan Stack, had sufficient structural strength to withstand the blast. The sturdy brick building also came through intact, except for a few blown out windows. Inset is that of a nearby plant, approximately the same distance from the blast area, rendered inoperative for several weeks due to a demolished chimney.

John E. Casey, chief engineer states in his report: "There occurred no damage to our generators, but considerable damage to our controls. Our stacks remained sturdy and functioned without interruption, despite the fact that the blast was a terrific one. Immediately after the blast, the power load was transferred to other of the company's plants and sources in the Eastern Power Network."

During the explosion, eighteen shells landed on the roof of this plant and three in the boiler room. One shell, landing on top of a boiler, later exploded. In spite of this danger, an emergency crew took over and, by early Monday morning, May 22nd, one generator was in operation with another put on the line two days later.

Prat-Daniel Self-Supporting Fan Stacks have weathered many catastrophies such as this, coming through hurricanes, tornadoes and explosions unscathed.

New Stuffing Box Cures High-Pressure Orifice Meter Leaks

A new orifice meter stuffing box, announced by the Pittsburgh Equitable Meter Div., Rockwell Manufacturing Co., greatly reduces meter maintenance and leakage troubles at the most frequent point of field service—the pen shaft which transmits the motion of the meter's float, and lies between high-working-pressure zones in the manometer and atmospheric-pressure zones in the chart case. It has been shown leakproof at working pressures as high as 5000 psi—pressures which invariably cause stuffing-box troubles, and pressures which are becoming more commonplace with the national expansion of natural gas transmission.

The heart of the new stuffing box is a combination packing and bearing machined from a new and remarkable synthetic plastic, known as Teflon. Teflon is a fluoromethylene polymer which is tough and chemically resistant to water and all reagents (even sulfuric acid) except the molten alkalis. It can take up to 450°F. But the properties of Teflon which solve the high-pressure meterman's woes are its waxy surface (very low coefficient of friction) and its perceptible, but minute, cold flow under pressure.

In the new design a spring-loaded follower sleeve compresses the Teflon bearing in a gland shaped very much like any conventional packing gland (see illustration). Teflon flows under pressure very slightly—acting in the manner of a packing material and adjusting itself to the stuffing box body and to the periphery of the shaft. This Teflon bushing which is tapered at each end may be turned end for end on the shaft and it will still line up perfectly, eliminating any bind.

The new principle in stuffing box design eliminates the necessity of lubricant as a sealing medium. Light oil or lubricant, however, can be applied to the shaft and will not harm its performance. Factory tests of this design without lubricant show no leakage under high pressure, and free rotation of the shaft under a torque of only 9.7 inch-grams. Many months of laboratory experiment with high pressure nitrogen did not disclose any leakage whatever in this new design. More than a year's field testing by several major pipeline companies and oil companies (measuring gas at cycling plants) has demonstrated outstanding performances on various kinds of corrosive gases with entrained liquid. At one of these cycling plants the new stuffing box is working at flow temperatures of 200 degrees and working pressure from 3600 to 4000 psi.

The stuffing box body and all component parts are made of stainless steel, thereby eliminating corrosion or rust. The shaft is hardened throughout, and ground to close

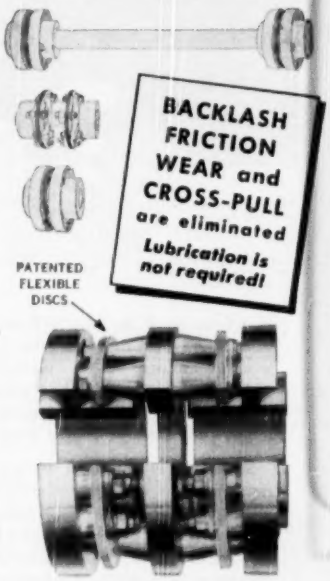
Continued on Page 54

THOMAS
Flexible ALL METAL
COUPLINGS
FOR POWER TRANSMISSION
REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
1 to 30,000 RPM

Specialists on Couplings for more than 30 years



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT.

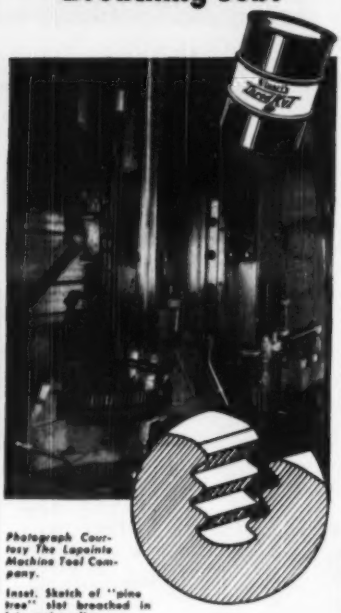
NO MAINTENANCE PROBLEMS.

ALL PARTS ARE SOLIDLY BOLTED TOGETHER.

Write for the latest reprint of our Engineering Catalog.

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

"ThredKut 99 Smooths out tough "PINE TREE" Broaching Job!



Photograph Courtesy The Lapointe Machine Tool Company.

Inset. Sketch of "pine tree" slot broached in jet engine disc.

HERE is one of the most difficult broaching jobs that the metal-working industry has ever tackled and solved — cutting the "pine tree" shaped slot in exceptionally tough alloy steel jet engine discs.

Stuart's THREDKUT 99 has rendered outstanding service for leading manufacturers in this field. Its combination of high anti-weld and high lubricity characteristics proved to be a 100% satisfactory solution to difficulties of this job.

What is your broaching job? The toughest ones can be handled better, and the easy ones are easier with the right Stuart products! Ask for Stuart's pamphlet OILS FOR BROACHING or call your nearby Stuart representative.

D. A. Stuart Oil Co.

2741 So. Troy St., Chicago 23, Illinois

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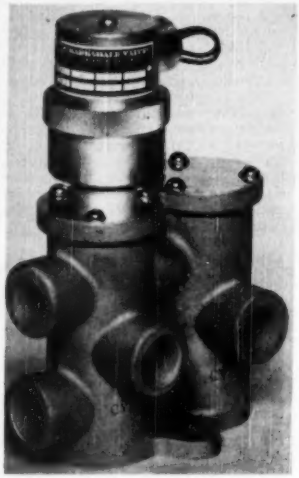
tolerances. The design makes it possible to unscrew the end-guide from the body and remove both shaft and Teflon bearing, and replace either or both of these parts, if need be, in the field. The shaft could not be replaced in former designs. If leakage occurred, the entire stuffing box assembly had to be replaced, thereby affecting inventory and operating costs.

So successful is the new stuffing box that its use will be standard on all Rockwell Emco orifice meters, for low as well as high pressure use. Packaged kits comprised of a new stuffing box and appropriate compensating links and pen arm are available for "converting" meters already in service.

Barksdale to Represent Meletron and Crescent

This cooperative plan among three manufacturers deserves the attention of industrial control users everywhere, because it promises definite benefits and savings to them. Here are specialists whose distribution problems are overlapping.



Meletron has gained a reputation of covering the pressure switch field with a most comprehensive line. Wherever a pressure or vacuum change must be transformed into electrical action, there is a Meletron switch to perform the function.

Although the Crescent 4-way solenoid valves (illustrated) are a relatively recent development, they have already proven their merit on tough assignments such as high speed continuous service on welding equipment in the automotive and related fields.

These 4-way valves are available for control of air, water, and light oil up to 150 p.s.i., in pipe sizes of $^1/_4$", $^3/_8$", $^1/_2$", and $^3/_4$" i.p.s.

Solenoids are of special design to withstand continuous operation of up to 600 cycles a minute. Records show performance of several million cycles without maintenance.

Barksdale brings to this combination a record of achievement in pioneering extreme pressure control with the famous "Shear-Seal" valves. The Barksdale organization, with headquarters at 4905 Santa Fe Ave., Los Angeles, has competent representatives in every major city in the U. S. and Canada.

This progressive program of three industrial controls manufacturers represents a

Just Published - - -

Addenda to 1949 Unified and American Screw Thread Standard

A SECOND EDITION of the Standard incorporating the addenda

The past year's experience in the application of the Standard has shown a need for amendments to prevent possible misinterpretations of text and illustrations, to facilitate the use of the tables, and to correct some misprinted figures. While these changes do not affect the intent of the original (1949) Standard, they have been published in a 16-page pamphlet for those who want the latest interpretations. Of these, the most important are:

- **Making the 1 in. 14 size an optional American Standard in the fine-thread series.**
- **Designating certain sizes of the extra-fine thread series as "UNEF."**
- **Deleting the 1/2 in. 12 NC and the 1 in. 12 NF from Classes 2 and 3.**
- **Adding a new table (25A) on page 65, giving Special Thread Major Diameter Tolerances.**
- **Conforming the column heading of Table 26 to those of succeeding tables.**
- **Revising the section on "limitations of Design" on page 87.**

Price of a set of addenda pages—50¢ (No discount allowed)

For owners and users of the original Standard, to whom the trouble of transforming their copy does not appeal, there is an amended standard embodying all the changes and designated as the SECOND EDITION.

Price—$3.00 ($2.40 to ASME Members)

AMER. SOC. MECH. ENGRS.
29 W. 39th St., New York 18, N. Y.

Date_____

Please send me the Publications checked:

——Addenda to 1949 Unified and American Screw Thread Standard $___

——Second Edition of the Standard, incorporating changes. ___

Note: Remittance should accompany orders for $2.00 or less.

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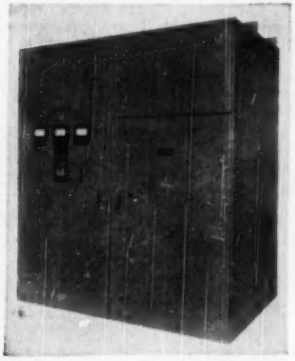
realistic approach to better industrial distribution, which is still the greatest single cost factor. We urge every alert engineer and production man to take advantage of the specialized experience offered through your trade publications by forward looking manufacturers. Your response is the key to better methods and lower costs.

Write for further technical information and present your own problems.

New "Slipsyn" Synchronous Motor Control

New "Slipsyn" full- or reduced-voltage synchronous motor control units, for operating and protecting all types of synchronous motor drives, are available from Westinghouse Electric Corp. They are supplied as factory-wired units, requiring only external connections when installed.



A new type ASR polarized slip-frequency relay, with associated control, provides automatic synchronization with maximum pull-in torque at the proper speed and phase relation, thus minimizing line disturbance. Pull-out protection is incorporated to stop the motor automatically if it pulls out of step. Provision for re-synchronization of the motor after pull-out can be made if desired, and if load conditions permit.

One thermal protective relay guards the stator against sustained overloads; another guards the rotor damper windings against failure of the motor to start. Time delay under-voltage protection can be supplied on all models.

With optional type BAL fuses, these units have interrupting capacities up to 250,000 kva, 4,800 volts, three phase, 60 cycles.

For further information, write Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pennsylvania.

Electro-Chemical Feed Control

When it is necessary to feed chemicals continuously and proportional to the flow of water entering a tank, you will find the New Permutit Electro-Chemical Feed Control well suited.

It is outstanding for its . . . (A) Accuracy of control, (B) Ruggedness which avoids failure due to frequent breakdown, (C) Flexibility permitting easy variation in the rate of feeding chemicals, (D) Absence of small measuring orifices that may be easily fouled by lime solution destroying accuracy of feeding, and (E) Prevention of chemical dust from escaping to atmosphere during time of charging chemical tanks.

Water flows through an integrating raw water meter. Integrator makes an electrical

Continued on Page 56

STAYING POWER
For hydraulic pressure, for boiler or desuperheater feed—use this Aldrich-Groff "POWR-SAVR" Controllable Capacity Pump.

ENGINEERS and plant managers — these men in particular — know that machinery must have *staying power*. Whereas breakdown or interrupted production costs money, *staying power* pays!

The automatic stroke-transforming action of the "POWR-SAVR" Pump (above) supplies only that capacity actually needed. As for mechanical reliability, over 500 of these Aldrich-Groff Units — many with as much as ten years of service — are successfully operating today.

Wherever high pressure pumping is required, use an Aldrich Pump. You, like the 500 satisfied users mentioned above, will profit from a good investment. For technical information, request Data Sheet 65.

Representatives: Birmingham • Bolivar, N.Y. • Boston • Buffalo • Chicago • Cincinnati Cleveland • Denver • Detroit • Duluth • Houston • Jacksonville • Los Angeles New York • Omaha • Philadelphia • Pittsburgh • Portland, Ore. • Richmond, Va. St. Louis • San Francisco • Seattle • Spokane, Wash. • Syracuse • Tulsa

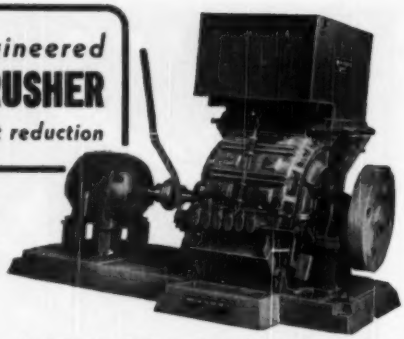
THE ALDRICH PUMP COMPANY

29 PINE STREET, ALLENTOWN, PENNSYLVANIA

All Aldrich Pumps Have STAYING POWER

There's a job-engineered
AMERICAN CRUSHER
for uniform . . . low-cost reduction

. . . of COAL, CLAYS, CHEMICALS, STONE, METAL TURNINGS, WOOD, DRY ICE, FOOD—hundreds of products or every description.



Metal Turnings Crusher—reduces long, curly turnings of steel, alloys, brass, aluminum, etc., to uniform chips for highest cutting oil recovery . . . increased scrap value.

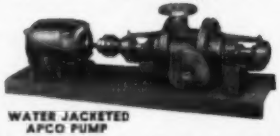
Laboratory Mill—for testing, pilot plant operation and waste reduction.

"AC" Ring Mill—with exclusive shredder rings—for uniform, high tonnage reduction. 500 TPH. "24 Series" ring or hammer crushers offer capacities to 50 TPH. . . . "30 Series" Hammermills to 100 TPH.

Write for complete information on the famous American line of crushers.

American PULVERIZER COMPANY
Originators and Manufacturers of Ring Crushers and Pulverizers
1541 MACKLIND AVE.
ST. LOUIS 10, MO.

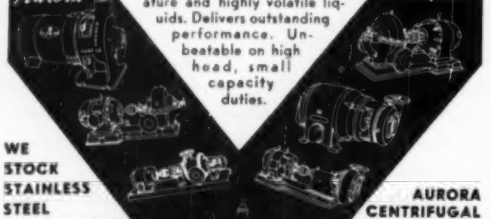
Making Warm Friendships on Hot Jobs



WATER JACKETED APCO PUMP
Developed especially for the efficient handling of high temperature and highly volatile liquids. Delivers outstanding performance. Unbeatable on high head, small capacity duties.

PUMPS "by Aurora"

For Every Purpose



WE STOCK STAINLESS STEEL APCO PUMPS
For the convenience of our engineer friends we carry for immediate shipment, popular sizes of Apco Pumps in STAINLESS STEEL.

AURORA CENTRIFUGAL PUMPS
are available in many types and sizes—all noted for their streamline coordination between impellers and shells.

Write for CONDENSED CATALOG "M"

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AURORA Always PUMPS
AURORA PUMP COMPANY
96 Loucks Street, AURORA, ILLINOIS

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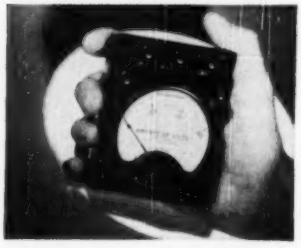
contact when a predetermined quantity of water has passed through the meter, thus starting the control unit and a time switch which limits the operating time of the control unit. The quantity of chemical solution is always proportional to the flow of water. The ratio of chemical solution fed can be varied by manually adjusting a knob on the dial of the time switch. The quantity of chemicals fed may also be varied by changing the density of solution in the chemical tank.

The dial gauge is part of the chemical control unit and is in the operator's view at all times. Where desired, a remote dial control can be purchased and mounted on a panel board. The second gauge will syncronize with the dial gauge on the control unit. For further information, write Permutit Co., 330 West 42nd St., New York 18, N. Y.

Type P-12 Portable Instruments

A new line of portable instruments, designated type P-12, is available from the Westinghouse Electric Corp. Rated in the two-percent accuracy class, the line utilizes both moving-iron and permanent-magnet moving-coil mechanisms in a compact molded case.



The line includes single and multiple range models. Ammeters are available in full-scale ranges from 20 microamperes to 50 amperes d-c., and from 5-milliamperes to 50 amperes a-c. For d-c voltages, the full-scale ranges run from 10 millivolts to 800 volts, with a-c ranges from 1.5 volts to 300 volts. Rectifier milliammeters are available in full-scale ranges from 0.5 to 10 milliamperes, and rectifier voltmeters from two volts to 800 volts.

The outline dimensions of the meter are: $3^{9}/_{16}$ inches wide, $5^{1}/_{4}$ inches long, and $1^{28}/_{32}$ inches deep for the d-c type. The a-c meter is the same size, except that the depth is $2^{9}/_{16}$ inches.

The complete line is magnetically shielded to permit use of the instruments on both magnetic and non-magnetic surfaces, and spaced as closely together as is required.

For further information, write the Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Hot Process Zeolite Water Conditioner

Cochrane Corp., 3142 North 17th St., Philadelphia, announces the availability of a new type of water softening equipment, combining the virtues of the two most popular types of industrial water softening—the Cochrane hot process softener and the Cochrane zeolite softener, long known for its simplicity and economy. In the Cochrane Hot Process Zeolite Water Conditioner the zeolite softener is used as a second stage following the first stage in which lime is the single reagent. This first stage precipitates the bicarbonates and magnesium in the water supply leaving the remaining hardness to be removed by the zeolite softener, utilizing salt as a regenerant.

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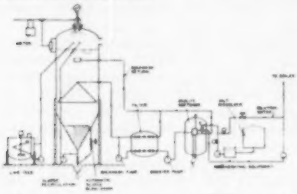
This unique combination of hot process and zeolite has been made possible by the fact that new high temperature resins used in the zeolite stage will withstand both the high temperatures and the pH values obtained in the hot process stage, something that former zeolite materials, whether natural or synthetic, were unable to stand beyond 120° F. without disintegration.

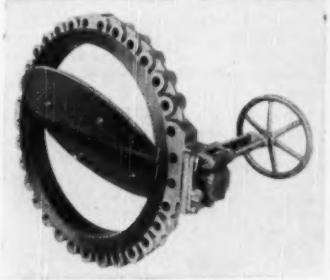


The advantages are many including saving in chemicals, saving in capital investment, lower CO_2 in the steam, less floor space and head room required, less operating attention, better control of phosphate excess in the boiler, lower alkalinity and only one chemical needed in the hot process.

The Cochrane Hot Process Zeolite Softener is particularly advantageous in the treatment of turbid surface water high in carbonate hardness and silica, for it combines economical softening, silica removal and clarification process in one apparatus.

Wafer Type Valves Designed to Resist Torque

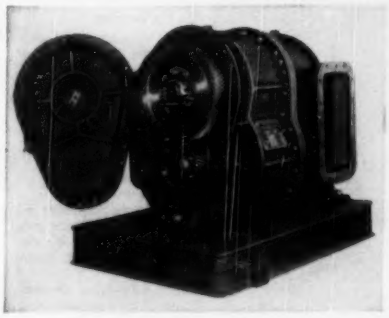
Working on the known principle that face-to-face dimension does not reduce torque, one-piece body casting valves have been developed that have many of the rugged features of the standard double flanged units. Vane, shaft assembly, handwheel control with self-locking worm and gear and flareout on body casting, which accommodates the large mounting bracket, is identical with double flanged valve.



In the open position the beveled streamlined vanes create a Venturi action. Pressure drop, compared with many other types of valves is low and they therefore show substantial savings in pumping power. There are no pockets to capture sediment, no change of flow direction to create turbulence. Freedom from turbulence reduces erosion and cavitation.

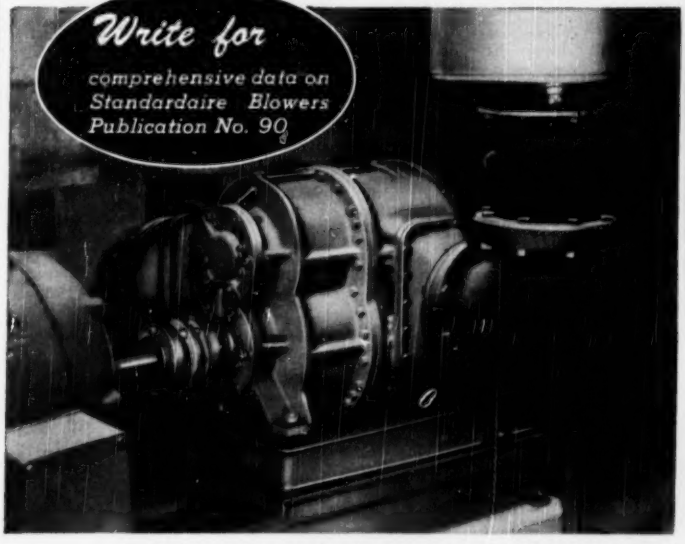
These valves, designated as No. 771, together with the more rugged double flanged units are used for air, gas, liquids, steam and semi-solids in the shut-off and regulation of volume and pressure; pressure relief; control of liquid level, back pressure, water hammer, steam hammer, constant differential pressure; regulation of pump, fan, engine and turbine output and control of automatic combustion. Made by R-S Products Corp., Wayne Junction, Philadelphia 44, Pa. *Continued on Page 58*

The STANDARDAIRE
PRECISION BUILT
Axial Flow BLOWER ~



Here's another important design feature of the Standardaire Blower —HEAT TREATED ALLOY STEEL TIMING GEARS—generated and shaved to extreme accuracy for quiet operation.

THESE helical gears keep the cycloidal form, screw type rotors of the Standardaire Blower in timed relation. There is no wind-up in the shafts between the rotors and gears as a very small percentage of the in-put power goes through the timing gears. The male or main rotor does the work and consumes the power; the female rotor acts simply as a valve or gate—further evidence of the finer features found only in the Standardaire Blower. The Standard Stoker Co., Inc. Dept. C4—370 Lexington Ave., 17, New York.



● Typical installation of a Standardaire Blower as installed in a malting plant

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• LATEST CATALOGS

Axonometric Drawing

John R. Cassell Co., 110 West 42nd St., New York 18, N. Y., has just issued a new pamphlet pertaining to Axonometric Drawing as made simple by the use of these Instrumaster Ellipse Stencils. This is the most comprehensive pamphlet issued on this line since it was introduced four or five years ago.

Kinney Car Unloader

Heyl & Patterson, Inc., 55 Water St., Pittsburgh 22, Pa., has just issued new Bulletin No. 2-5-KCU describing their Kinney Car Unloader. Year round the Kinney Car Unloader can be used to spot cars over the hopper and unload damp, wet coal . . . . in the winter, to remove frozen coal out of hopper car without the use of heat. Enables one man to unload a 70-ton car of frozen coal in 20 minutes or less.

Data on New Swivel Spout Offered by Richardson

The Richardson Scale Co., Clifton, N. J., has just issued a data sheet containing complete specifications for a new dust-tight Swivel Spout. A large three-plan diagram is included, and all dimensions are clearly marked.

The dust-tight Swivel Spout is designed to eliminate routing of batches by dusty swivels or conveyor plows. Increased scale flexibility is reported obtainable by using the spout to "chute" pre-weighed discharges to different bins or stations, to deliver from a bin to several different scales, or to deliver pre-weighed discharges to two different delivery trucks. Numerous other applications in feed mills, grain elevators, and industrial plants are possible.

Remote automatic positioning of the spout can be synchronized with other functions by means of a timer. The Swivel Spout is available with either manual or automatic controls. For a copy of the data sheet on this spout, write to Richardson Scale Co., Clifton, N. J., ask for product data sheet No. 5001.

Embrittlement

The current status of embrittlement, its causes and control, is discussed in a new informational bulletin released by Allis-Chalmer water conditioning department.

The bulletin tells how to distinguish between steam boiler cracks caused by corrosion-fatigue and embrittlement; explains the prevailing conditions that cause intercrystalline cracking of boiler metal, and describes recent developments including use of nitrates as efficient embrittlement inhibitors and the use of the embrittlement detector unit.

The bulletin concludes with this observation: "The power plant engineer will do well to consider the over-all problem of embrittlement as it may strike unexpectedly. It appears that if a riveted drum boiler has less than eight years of operating history under consistent water conditions, an embrittlement test is imperative, especially if the proper ratios have not been consistently held.

"If a riveted drum boiler has a consistent operating history over a period of more than eight years under which water conditions have been consistent, it is highly probable that the necessary combination of factors for embrittlement do not exist and continued operation under the same ratios should be safe. If any doubt exists, an embrittlement test should be conducted under the direction of a competent supervising laboratory, licensed under the existing patents.

Copies of "Embrittlement—Current Status...Its Causes and Control," Bulletin 28×7466, are available upon request from Allis-Chalmers Mfg. Co., 949 S. 70th St., Milwaukee, Wis.

Hydraulic Cylinders

New Bulletin CS-849 by Ledeen Manufacturing Co., describes the application of hydraulic cylinders in a concrete block machine. The machine is illustrated, and details and operation of the cylinders discussed.

For free copies, write to this publication or to Ledeen Manufacturing Co., 1600 So. San Pedro St., Los Angeles 15, Calif.

Custom Built Electrical Enclosures

A sixteen-page booklet containing over 40 illustrations plus descriptions of custom built sheet metal electrical enclosures has recently been released by The Kirk & Blum Mfg. Co., Cincinnati, Ohio.

Among the many items illustrated are control desks, cubicles, electrical cabinets, and enclosures, power distribution and control panels, switch gear housings, louvres, test stands, controls and desks, outdoor electrical enclosures, transformers, tanks and instrument panels.

In addition to these, The Kirk & Blum Co. fabricates cabinets, bases and other subassemblies large or small for electrical equipment manufacturers.

A free file copy of this 16-page catalog is available on request to The Kirk & Blum Mfg. Co., 2850 Spring Grove Avenue, Cincinnati, Ohio.

"Users Invent Uses," Says New "How To Handle It" Issue Of Material Handling News

The "How to Handle It" issue of the Material Handling News, external house organ published by the Industrial Truck Division of the Clark Equipment Co., Battle Creek, Mich., is fresh off the presses and ready for distribution. It's striking cover immediately stimulates lively interest and impels what is bound to be profitable perusal of the contents.

Based on a Clark-coined theme, "The usefulness of a fork-truck is limited only by the ingenuity of the user," the new Material Handling News—Volume 8, No. 1—points out that many of the handling devices and methods now in use originated in the minds of fork-truck users. Of these users, says the editorial introduction to this new publication: "... more power to them, for they are of the splendid breed of discoverers and pioneers—indeed, their tribe are the builders of progress."

Applications of Clark fork-lift trucks and attachments are pictured lavishly throughout the new issue of the Material Handling News. Clark machines are shown at work throughout the world, and in occupations that to many fork-truck users will be new and exciting.

The magazine is sparing of words and generous with illustrations. It features, among other things, Clark's new Bartel Device for handling newsprint and other materials rolled around a hollow core; a novel crate clamp which eliminates the use of pallets; the new Clarkette-5 as used in wholesale grocery warehouses for order-selection work; Clark's new Universal Clamp and its adaptations, handling cartons without pallets, drums, and cotton bales in a number of different combinations.

A double-page spread of Clark fork-lift trucks at work in foreign countries is of out-

Continued on Page 60

ALUMINUM

SOLVES MANY TOUGH PIPING PROBLEMS

In recent years, aluminum and aluminum alloys have grown rapidly in importance as piping materials in many industries, including manufacturers of chemicals, foods, soaps and cosmetics, petroleums, textiles, explosives, rubber, paints and varnishes.

There are many reasons for this. Aluminum offers high strength, light weight, passivity when in contact with various corrodents, resistance to corrosion, absence of sparking characteristics, and low cost in comparison with other metals that have the same inherent qualities.

For example, in chemical plants, aluminum offers great resistance to corrosion, and it is passive to a large number of corrosive fluids where other metals tend to catalyze. Its corrosion products do not cause discoloration. This is important where maintenance of product color is of primary importance.

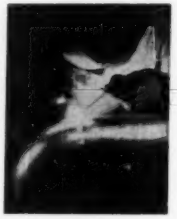
In food plants, aluminum resists the corrosive action of most food products such as acetic and nitric acids, oils, milk, beer, and fruit juices. It protects against color contamination and helps prevent rancidity.

In the petroleum industry, aluminum piping resists the corrosive action of hydrogen sulfide, sour crude oils, mineral oils and liquid fuels.

Aluminum piping materials are available in a variety of alloys including 2S, 3S, 61S, 63S, and Alclad 3S. Each is particularly suited for certain applications. And, since the physical properties vary with each alloy used, individual applications should be analyzed carefully to determine the correct alloy needed for the job.

So that every user can realize the advantages of all-aluminum piping systems, and also have the benefits of greater strength, greater safety and permanently leakproof joints afforded by welded construction, TUBE-TURN Welding Fittings and Flanges can be provided in all the alloys listed above. It's the most complete line available to industry.

TUBE-TURN Welding Fittings and Flanges of wrought aluminum and aluminum alloys are available in many types and sizes, and in standard and extra heavy weights. They are now widely used in many industries.



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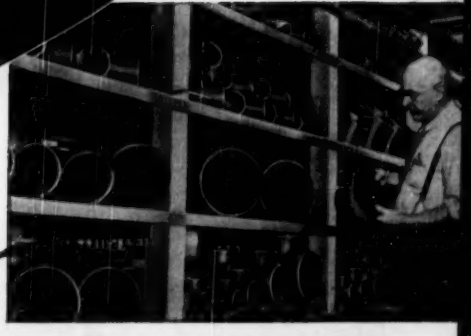

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PROPER DESIGN– still the most important ingredient

Despite the great advances in the use of alloy steels, the shape and proportions of a part are still of more vital significance than its material.

In an overall view, we should rate Design (1), the choice of the proper Steel (2), and its Treatment (3), in that order of importance. All are, of course, matters of great concern, but if the design is wrong then the proper choice of steel and its successful treatment serve no useful purpose.

What is the metallurgical significance of poor design? It promotes unhealthy stress concentrations and troublesome variations in the proportions of adjacent parts.

To stress the relationship of good design to metallurgical and economic factors, we have prepared a book helpful to designers, showing by sketches a great many factors in good and poor design which influence the behavior of a part in service.

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standing interest and covers snow-removal, airplane-engine maintenance, l.c.l. operations by the Danish State Railway, to decorating streets for Rio de Janeiro's famous Carnival Week.

The tremendous value users have found for fork-lift trucks on so-called "odd jobs," also is illustrated and explained. From this set of pictures and their captions, readers of the Material Handling News are almost certain to develop ideas for more complete use of their own equipment.

Included in this publication is a map showing the location of each of Clark's many dealers in the United States, together with a directory listing their names and addresses. In the Export version, foreign distributors are located geographically, along with their names and addresses.

A copy of this invaluable publication on modern materials-handling methods and machines will be sent promptly upon receipt of requests made on business letterheads. Signatures should include the writer's position in his company. Requests are to be addressed to the Industrial Truck Division, Clark Equipment Co., Battle Creek, Mich.

Flexible Shaft Assemblies

The F. W. Stewart Mfg. Corp. has just issued a 36-page bulletin depicting a number of Flexible Shaft assemblies designed by their engineering staff. Drawings and specifications are given in complete detail; also tables and illustrations that furnish all the dimensions, types of cable, casing and basic data needed when applying a flexible shaft to your product.

Many of these flexible shaft assemblies are now being used on remote control devices for electronic equipment, airplanes, and automobiles; while others are serving as power shafts on many types of industrial machines and products. Their many potential uses can easily be recognized by the manufacturer, engineer, or designer.

For a copy of "Flexible Shaft Assemblies" write F. W. Stewart Mfg. Corp., 4311 Ravenswood Ave., Chicago 13, Illinois.

Economy Mixed Flow Volute Type Pumps

Mixed Flow Volute Type Pumps are the subject of a new catalog issued by Economy Pumps, Inc. Designed for high speed transfer of liquids that may contain light solids, Mixed Flow Pump applications include sewage disposal, irrigation, raw water pumping, reduction, and similar pumping operations. The catalog features construction details, photographs, drawings, and a selection table covering applications of Mixed Flow Pumps of various sizes. Catalog No. F-1049, Economy Pumps, Inc., Hamilton, Ohio.

Cycloidal Vacuum Pumps

Cycloidal Vacuum Pumps are covered by Bulletin 50-B-13 just issued by Roots-Connersville Blower Corp., Connersville, Ind. This type of positive displacement pump is designed especially for heavy-duty suction service, such as required in paper mills, and is capable of producing vacuums from 4" to 26" Hg., with high volumetric efficiency, according to claims of the manufacturer.

Following a foreword covering Roots-Connersville's extensive experience in building vacuum-producing units, the next four pages are devoted to the structural advantages claimed by the manufacturer, accompanied by several illustrations relating to these features. Typical performance curves are also shown here.

On page 7 there is a discussion of the Type RCV-2 compound unit with a cut and line

IMPROVED STANDARDS URGED

Thomas D. Jolly, vice president of the Aluminum Company of America and president of the American Standards Association, said that American business men are gambling millions of dollars daily on the purchase of materials because they are unaware of up-to-date standards needed to guide their decisions. He urged broader use of standards data by management, production and purchasing executives. In his own company, he continued, such methods made it possible to reduce stocks of more than 800 varieties of lubricants to a standard stock of only 120 items. In one plant, 1,070 items were eliminated through standardizing only fifteen classifications of stores. (From N. Y. Times)

Mr. Jolly told this to the convention of the National Association of Purchasing Agents on June 12 in Cleveland.

The ASME has recently published The American Standard for Plain Washers (B 27.2 1949) which lists 77 standard sizes of washers. The adoption of this Standard will reduce to 77 sizes the *25,000* sizes for which tooling is now available. Price per copy is 25¢.

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drawing showing proper piping layout. The following two-page spread presents numerous installation views in U. S. and Canadian mills, illustrating a variety of paper mill applications, including couch and press rolls, flat boxes, and felt conditioners. On the following page, other R-C equipment, used in applications important to paper mill operation, is also discussed.

The inside back cover carries a cut of a large R-C centrifugal exhauster as used in a New York paper mill's central vacuum system, a method of providing suction for a battery of paper machines that has gained popularity in some large mills, and for which R-C centrifugal units are well suited, according to the maker.

Economizers

The "Premier Diamond" Line of Economizers is described in a new catalog (No. 169) just issued by Green Fuel Economizer Co., Inc., Beacon, N. Y. Both Cast Iron Tube Economizers (Type 25) and Steel Tube Economizers (Type 12) are covered in detail. The advantages of the diamond shape tubes and the streamline flow of gas and soot blower steam are discussed; also the tube arrangement which makes the entire outside surface of each tube visible during inspection. For those operating at high pressures, the high pressure tube joint with its special sealing ring will be of particular interest.

Economy Sump Pumps

Construction details, applications, and detailed installation drawings of Economy VSL and VX general service Sump Pumps are featured in a catalog released by Economy Pumps, Inc. These pumps are suitable for automatic drainage of pits, basements, and similar constructions. A selection table for specific application of pumps, ranging in capacity from 30 to 150 U. S. gallons per minute, is contained in the catalog. Catalog No. E-748, Economy Pumps, Inc., Hamilton, Ohio.

Pressure Reducing and Regulating Valves

A. W. Cash Valve Mfg. Co., Decatur 60, Ill. announce the Cash-Acme's latest Bulletin No. 283. This bulletin announces changes, additions and improvements in a particular line of pressure reducing and regulating valves, which are suitable for domestic and many industrial uses.

The bulletin also announces a completely brand new, patented, automatic reseating relief valve. This new valve affords fully automatic temperature and pressure relief for both domestic and industrial type water heaters.

Wool Card

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., has available a four-page folder on Newport News Wool Card containing illustrations, descriptions and sketches of the three-card set.

Armco Perforated Pipe for Controlling Ground Water

A new 24-page illustrated booklet, Armco Perforated Pipe for Controlling Ground Water has been published by Armco Drainage & Metal Products, Inc.

It describes how harmful ground water can be controlled to provide stable roadbeds and dry subgrades, for airports, streets, recreational areas and industrial sites. Photographs show typical pavement and roadbed failures caused by ground water.

Pointing out that underground water conditions vary greatly, seven pages of dia-

Continued on Page 62

When Surface Roughness is Important in Your Shop

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If you want versatility in a surface roughness measuring instrument, you'll want the Profilometer.

2. By no other measuring method can you get roughness ratings *as fast* and *as accurately* as with the Profilometer. Its normal tracing speed is much faster than that of any other instrument of its type. Throughout the tracing operations, direct dial readings provide precise measurements in microinch units (millionths of an inch).

If you want speed and dependable accuracy in rating surface roughness, you'll want the Profilometer.

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grams show typical methods of treating subsurface drainage problems.

Following a discussion of the primary advantages of Perforated Pipe—structural strength, resistance to impact, strong joints, controlled infiltration area and economical installation—the booklet gives recommended installation methods.

Highway, construction and railway maintenance engineers will find this book a handy reference manual. Copies can be obtained by writing Armco Drainage & Metal Products, Inc., Middletown, Ohio or "Mechanical Engineering."

New Metal Forming Process

"Marform, The New Metal Forming Process" is the title of literature published by Hydropress, Inc. The 12-page folder which is just off press, explains extensively the new rubber pressure deep drawing method and its technical and economical advantages. Cost analyses of Marforming versus conventional methods—drophammer, spinning and steel draw dies—and many illustrations supplement the interesting brochure. Copies can be obtained from Hydropress, Inc., Marform Department, 570 Lexington Ave., New York 22, N. Y.

Baldwin-Sonntag Universal Testing Machine

Bulletin 310, which describes the new, low-cost Model 60-H Baldwin-Sonntag universal testing machine of 60,000 lb. capacity, is announced by The Baldwin Locomotive Works, Testing Equipment Department, Philadelphia 42, Pa. This 4-page bulletin explains and illustrates the operation of the testing machine, its controls and accessories, emphasizes its features and gives specifications.

Flow Meters

A new flow meter bulletin, released by the Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill., fully illustrates and explains flow measurement problems and their solution. Meter bodies, differential devices and reading instruments are fully described and a special section is included on wide range and reverse flow. The numerous illustrations in the book relate an informative pictorial story on fluid flow measurement. Write for the Republic Data Book No. 702.

New Michigan Automatic Checking Recorder

A two-page technical bulletin (Bulletin MTR-50) describing the new Model MTR Michigan Automatic Checking Recorder is available from Michigan Tool Co., 7171 E. McNichols Road, Detroit 12, Mich. Three photos and text clearly illustrate major features and controls of the recorder, which incorporates a new all-electric chart drive for increased accuracy in making permanent chart records of involute tooth forms, tooth spacing, leads, contours, diameters, thread forms, etc. Method of machine setup and operation is fully described.

ADSCO "Corruflex" Packless Expansion Joints

New 16-page Bulletin issued by American District Steam Co., North Tonawanda, N. Y., No. R-35-51 explains design and construction of "Corruflex", ADSCO's corrugated packless expansion joint that requires no maintenance. Complete description of line includes sizes, temperature and pressure ratings, dimensions and weights. Simplified selection charts make it easy to determine proper joint for most applications. Recommended installation practice is summarized together with pertinent engineering information. Illustrated with photos of types, cutaway view and typical installations.

Steam Hook-Ups

Sarco Co., Inc., Empire State Bldg., New York 1, N. Y., has just published the sixth enlarged edition on Steam Hook-Ups for Steam Traps, Air Vents, and Industrial Temperature Controls, with additional valuable technical information. Copies are offered free to maintenance engineers who write on their firm's letterhead.

Cochrane Issues Bulletin on New Water Conditioner

A new bulletin, describing the new Cochrane Water Conditioner, which combines the advantages of both hot process and zeolite softening, is announced by Cochrane Corp., 3142 No. 17th St., Philadelphia. The bulletin describes the Cochrane Hot Process Zeolite Water Conditioner, a two-stage softener in which the first stage is the hot process, using lime or Dolomitic lime, followed by the zeolite softener, which reduces the residual hardness to zero. Savings in capital investment, in chemicals, in floor space and head room needed, and in operating attention required are claimed, as well as lower alkalinity and better control of phosphate excess in the boilers.

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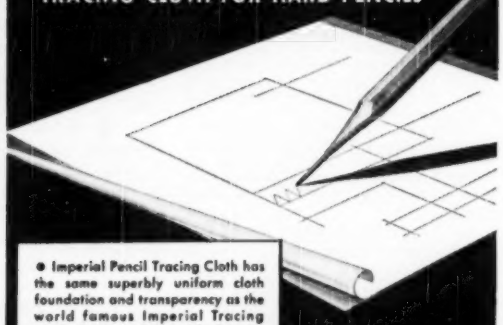

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LETTER SYMBOLS FOR AERONAUTICAL SCIENCES
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This new Standard is a revision and extension of the 1930 edition. The symbols, alphabetically listed in two main tables, are for 400 primary concepts and secondary concepts. For convenience in using the Standard, Table I includes the dimensional characteristics of the various concepts in terms of mass, length, time and temperature; indications of agreement with other current standards; and helpful remarks and definitions. There is also an alphabetical list of symbols used as subscriptions to represent secondary concepts.

LETTER SYMBOLS FOR HYDRAULICS
Z10.2—1942 **45¢**

These 170 letter symbols include the general symbols for the field; also those for (1) hydraulic structures, (2) hydraulic machinery, and (3) hydraulic models.

LETTER SYMBOLS FOR MECHANICS OF SOLID BODIES
Z10.3—1948 **30¢**

These 70 symbols are for concepts in mechanics of solid bodies.

LETTER SYMBOLS FOR STRUCTURAL ANALYSIS
Z10.8—1949 **35¢**

This Standard makes available the 77 approved letter symbols for structural analysis.

LETTER SYMBOLS FOR HEAT AND THERMODYNAMICS INCLUDING HEAT FLOW
Z10.4—1943 **65¢**

The list includes general letter symbols, as well as those primarily used for heat and thermodynamics, for heat flow, and for radiation.

LETTER SYMBOLS FOR PHYSICS
Z10.6—1948 **$1.00**

The more than 900 symbols in this Standard include all common terms in elementary physics and some in advanced physics and related fields.

LETTER SYMBOLS FOR CHEMICAL ENGINEERING
Z10.12—1946 **50¢**

Presents a standard system of symbols and nomenclature covering unit operations of chemical engineering.

ABBREVIATIONS FOR SCIENTIFIC AND ENGINEERING TERMS
Z10.1—1941 **45¢**

Establishes rules to be observed when using abbreviations; lists 277 letter symbols.

GRAPHICAL SYMBOLS

Simplification is the keynote of these 1949–1950 Standards. To meet present requirements, each Standard has been revised and expanded. The symbols themselves have been simplified and rearranged alphabetically with heads in major divisions. A one-weight line, neither heavy or light replaces the two different weight lines which were recommended in the 1941 standard.

GRAPHICAL SYMBOLS FOR WELDING AND INSTRUCTIONS FOR THEIR USE
Z32.2.1—1949 **50¢**

In addition to providing the approved symbols for indicating concise and precise information on drawings, this 1950 Standard gives complete instructions for their proper use. Contents: Basic symbols; Basic types of joints and welds; Location significance of arrow; Location of weld with respect to joint; Method of drawing symbols; Use of inch, degree and pound marks; Use of (1) Symbols without references, (2) Weld-all-around symbol, (3) Field weld symbol and (4) general notes; Weld proportions; Finishing of welds; Location of weld symbols; Combined weld symbols; Designation of special types of welds; Location of dimensions of filler, groove, lead, plug, slot, spot, seam, projection, flash and upset welds on drawings.

GRAPHICAL SYMBOLS FOR PLUMBING
Z32.2.2—1949 **40¢**

A standard method of indication for plumbing fixtures and allied items is provided by the 69 symbols in this Standard.

GRAPHICAL SYMBOLS FOR PIPE FITTINGS, VALVES AND PIPING **Z32.2.3—1949** **40¢**

This enlarged list of 71 symbols contains the symbol standards required by present day industry.

GRAPHICAL SYMBOLS FOR HEATING, VENTILATING AND AIR CONDITIONING
Z32.2.4—1949 **40¢**

This Standard lists the 81 symbols which are nationally recognized and which meet the evergrowing requirements of the industries in the fields.

GRAPHICAL SYMBOLS FOR RAILWAY USE
Z32.2.5—1950 **75¢**

This new American Standard represents a compilation and correlation of the 275 symbols used by engineering and signal divisions of various American railroads for indicating items in: agriculture, ballast, boundary and survey lines; bridges and tunnels; buildings and structures; cartography; culverts, sewers, etc.; derails; electrified lines; fences; fire prevention; highways and crossings; hydrography; lead-outs; bolt locks; cranks and deflecting bars; lighting; mines; miscellaneous devices applied to tracks; fixtures; oil and gas; pipe and wire lines; water supply and pipe lines; pole line wire; railways; relief; signal supports; sign boards and posts; switches; wayside fixtures; and wayside signal operating characteristics.

GRAPHICAL SYMBOLS FOR HEAT-POWER APPARATUS **Z32.2.6—1950** **35¢**

This latest addition to the collection of Graphic Symbols Standards contains 44 symbols which are suitable to the whole industry.

ABBREVIATIONS FOR USE ON DRAWINGS
Z32.2.13—1946 **$1.00**

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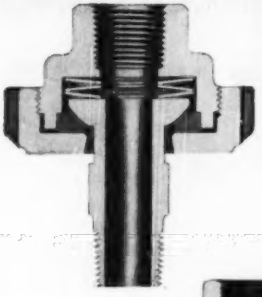
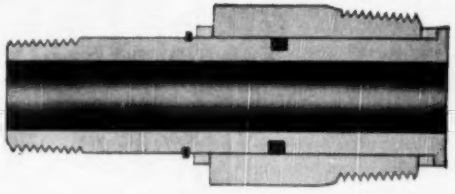
A complete range of design

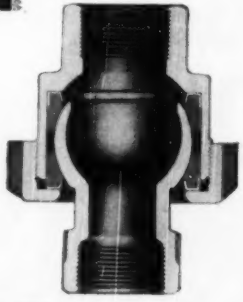
Select the one fitted to your specific needs



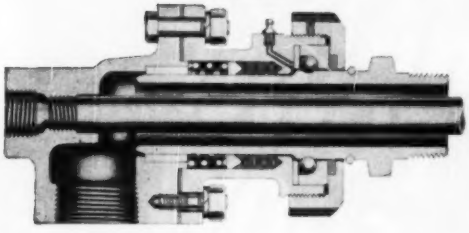
Barco Rotary Swivel Joints for use with air, oil, gas, steam, water and other fluids provide slow rotation with side flexibility.



Barco Swing Joint for hose reels, loading and unloading lines, and for tank cars and trucks—compact, inexpensive, durable.



Barco Flexible Joints for conveying oil, steam, gasoline, water, tar, corrosive acids and alkalis —where flexibility in piping is required.



Barco Revolving Joints supply steam, gas or other fluids from a fixed supply pipe to a rotating drum or member with low friction "drag." Sizes from ¼" to 5".

There is a Barco Joint for each particular problem in pipe flexibility. Different designs are available for:

- **Combined angular and swivel motion**
- **Swivel and slow rotation combined with angular motion**
- **Swing action with no side flexibility**
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There's a Barco Joint to handle any type of fluid with wide temperature and pressure ranges and a variety of metals and gasket materials. For more information about this *complete* line of joints, write Barco Manufacturing Company, 1821H Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal.

BARCO THE ONLY TRULY COMPLETE LINE OF FLEXIBLE, SWIVEL AND REVOLVING JOINTS

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40,000 BUYERS

WILL BE LOOKING FOR YOU

at the . . .

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NATIONAL EXPOSITION OF POWER & MECHANICAL ENGINEERING

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More than 40,000 key executives, engineers, and operating personnel will attend the 1950 National Power Show. From far and wide they'll come . . . keenly interested to see and learn about the latest equipment, methods, and supplies, low-cost production and use of steam, electric, and mechanical power. New cost-saving ideas were never so important to industrial men as now. They know from past experience that the Power Show is the one place to get the most practical suggestions in the least time.

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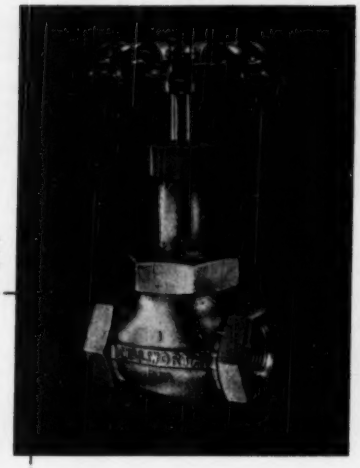
in conjunction with the Annual Meeting of the Society in New York City

Management International Exposition Co., Grand Central Palace, New York 17 N. Y.

IDENTIFICATION DISC: An aluminum marking plate on all Walworth No. 225P's facilitates inventory control and makes reordering quick and positive.



take a good look at the Walworth "500 Brinell" no. 225P Globe

NEWLY DESIGNED HANDWHEEL: Patented air-cooled, finger-fit handwheel affords sure grip even with greasy gloves.

– the Toughest Bronze Valve Your Money Can Buy

The stainless steel, corrosion resistant seats and discs are heat treated to a hardness of 500 Brinell – hard enough to scratch glass and crush nails! The valve can be closed on sand, slag, and pipe scale without injury to the seating surfaces. "Wire drawing" is practically eliminated. All parts are accurately machined and gaged. Years of tight, positive shut-off are assured.

Available in both globe and angle types (angle type: No. 277P) in sizes ¼" to 2", this quality valve is recommended for 350 lbs. W.S.P. at 550 F, and 1000 lbs. non-shock service on cold water, oil, gas, or air.

For full data on this long-life, economical Walworth Bronze Valve, see your local Walworth distributor, or write for Circular.

IMPROVED PACKING: Molded packing of lubricated asbestos reinforced with copper wire. Suitable for practically every service. Valves can be repacked under pressure when fully opened.

note these 7 Great Features

HEXAGONAL UNION BONNET CONNECTION, DEEP STUFFING BOX AND RUGGED STUFFING NUT: Union bonnet connection eliminates any chance of distortion or leakage even though valve is repeatedly taken apart and reassembled.

OVERSIZE STEM: The high-tensile strength silicon-bronze stem assures long life and protection against wear.

SEATS AND DISCS: Plug type seats and discs of stainless steel, heat-treated to 500 Brinell hardness and machined simultaneously to a mirror-like finish, with accurate tapers assures tight positive shut-off with minimum handwheel effort.

EXTRA STRONG BODY: Made of Composition M (ASTM B61) bronze. Thick walls and rugged hexes provide a high safety factor. Valves undergo hydrostatic shell test of 1,000 psi.

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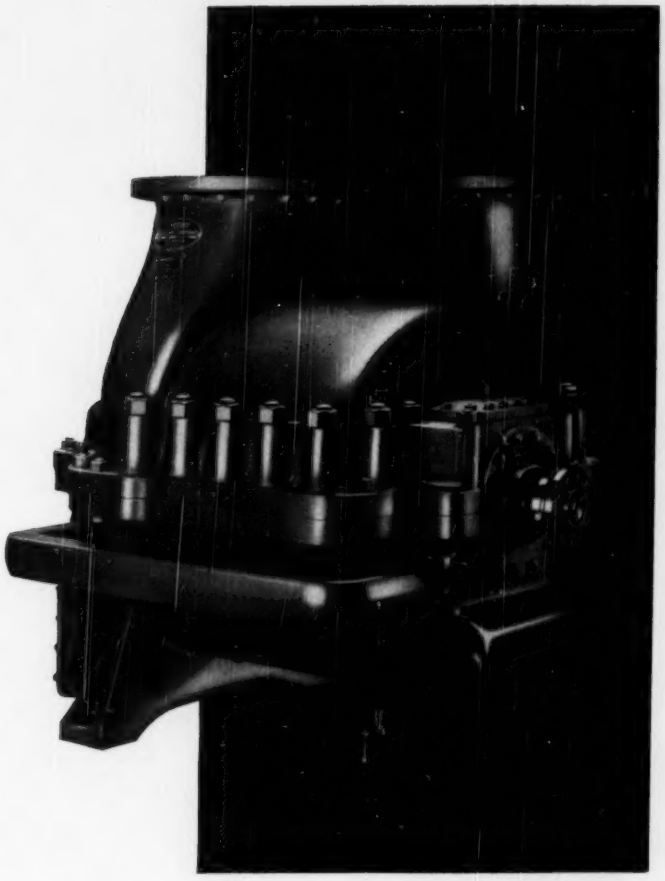


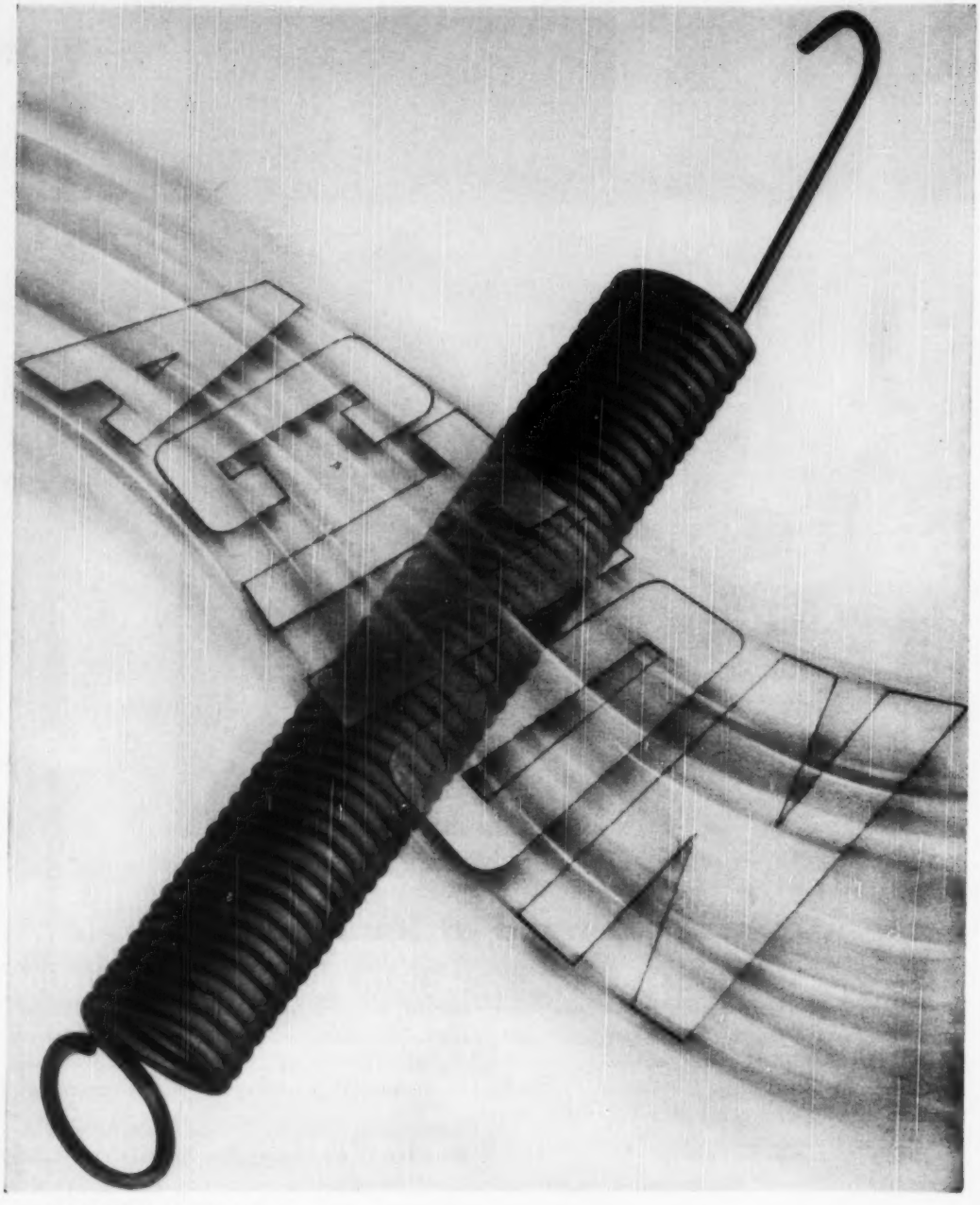
It's an old hand at handling gas

If gas compression is your problem, you can't do any better than a Carrier Centrifugal Gas Compressor. The Centrifugal Compressor was pioneered by Carrier. Today's Carrier Centrifugal is backed by more than 25 years of design, development and operating experience. And it shows!

There is only one major moving part in the Carrier Compressor. The few wearing parts are designed for maximum life and low maintenance costs. All bearings are totally enclosed. Main shaft seals are specifically designed to fit each type of application. Dust, dirt and rain can't get in. You can save the cost of a protective housing. And because there's almost no vibration, elaborate foundations are unnecessary.

The Carrier Centrifugal Gas Compressor is dependable. It does not require constant attendance. Labor for operation and maintenance is kept to a minimum. Some of the first Carrier Centrifugal Compressors built—over 25 years ago—are still in operation. Carrier Corporation, Syracuse, N. Y.

CENTRIFUGAL COMPRESSORS **Carrier** REFRIGERATION EQUIPMENT



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CLAMPS · WIRE FORMS

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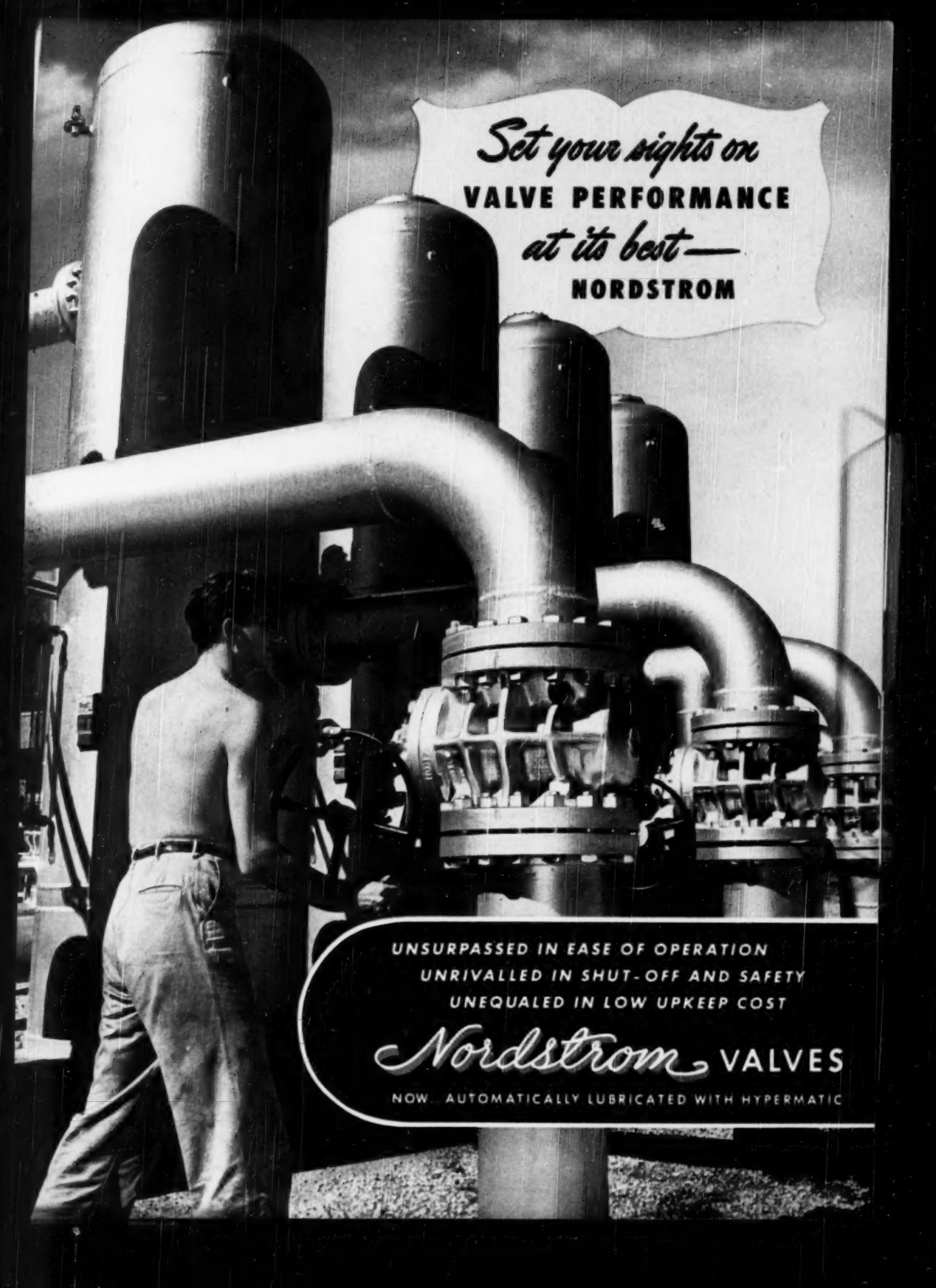
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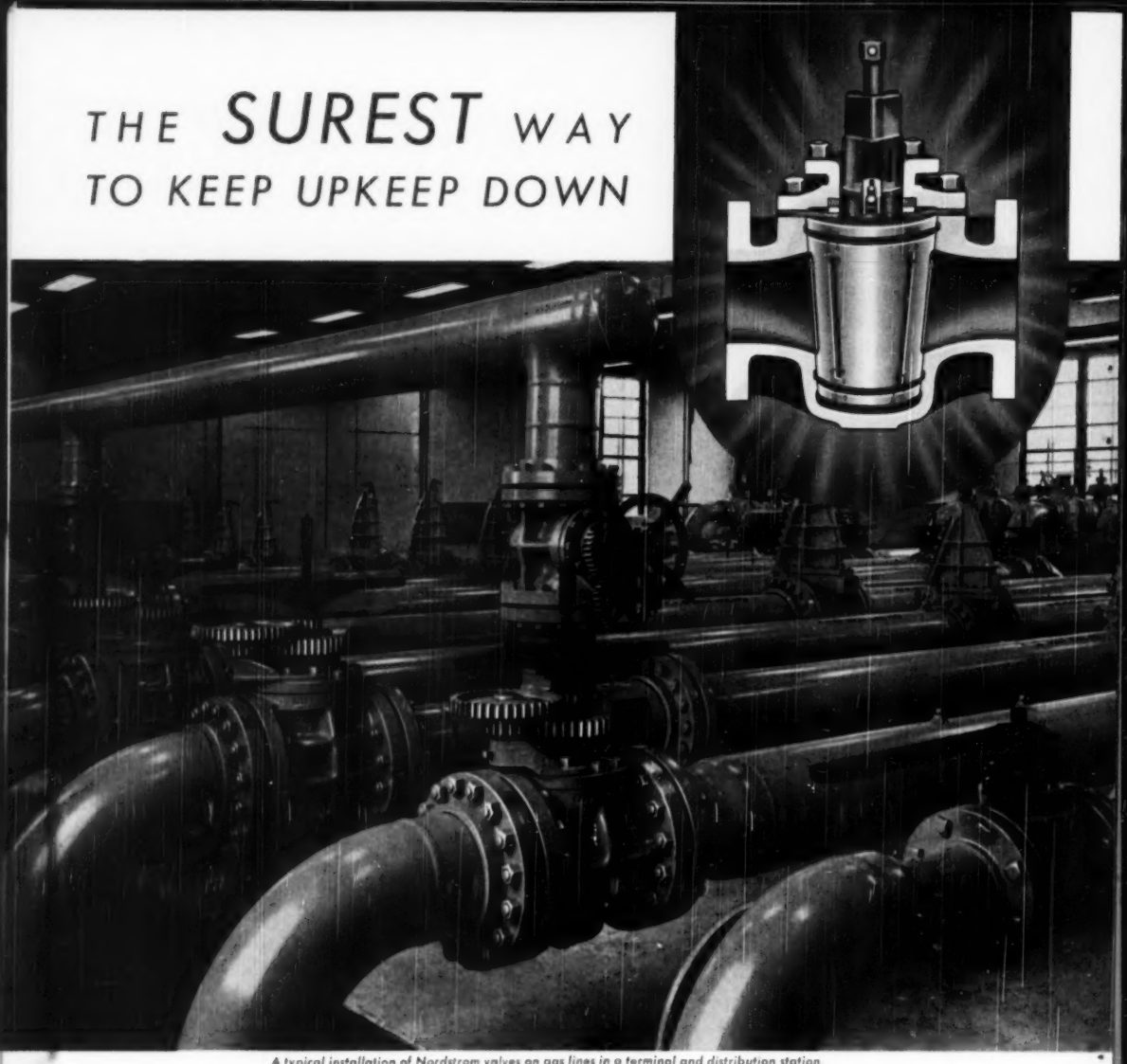
NOW... AUTOMATICALLY LUBRICATED WITH HYPERMATIC

THE SUREST WAY TO KEEP UPKEEP DOWN



A typical installation of Nordstrom valves on gas lines in a terminal and distribution station.

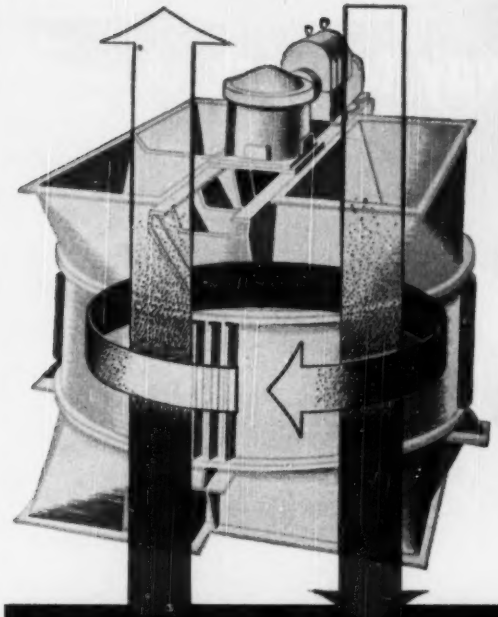
20-year average OF NORDSTROM PARTS REPLACEMENTS

less than ½ of 1% of valve purchases

In a recent audit of sales of Nordstrom valves extending back over a period of 20 years it was found that the ratio of repair and replacement parts was less than ½ to 100. Replacement parts were principally for valves in highly erosive services and for high temperatures where drastic conditions prevail. In other words the repair parts have over a period of 20 years equalled 46c to each $100.00 worth of valves purchased. This is indicative of the amazing low cost of upkeep as compared with other types of valves requiring frequent renewal of seating parts, packings, stems and occasional re-welds. *Nordstrom repair parts over a period of years are about one-tenth cost as compared with other valves.*

Nordstrom VALVES

Nordstrom Valve Division
ROCKWELL MANUFACTURING CO.
400 N. Lexington Ave., Pittsburgh 8, Pa.
District offices in all principal cities



this preheater can save you money whatever your fuel

the *Ljungstrom* AIR PREHEATER

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves the heat is transferred from the waste gases to the incoming cold air.

All fuels burn better with preheated combustion air, and it is a "must" for many of them, such as high moisture powdered coal. In addition, the *continuous regenerative counterflow* principle of Ljungstrom permits reliable operation at low exit gas temperature. This assures the greatest possible heat recovery . . . reduces the amount of fuel required.

The efficiency and reliability of the Ljungstrom air preheater is a matter of record in industrial and utility plants throughout the country. That is why every year a constantly increasing percentage of the installed boiler capacity is equipped with Ljungstrom air preheaters.

If you are planning a new installation, or modernizing your present one, our engineers will welcome the opportunity to show you how the Ljungstrom can raise the efficiency of your plant.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

he was on his way to work ..as usual

Usually he was a careful fellow. But this morning he took a chance. It was one chance too many.

That's the way it is with most accidents . . . whether on the highways, in the home or at work. When you take a chance you take your life in your hands.

Accidents don't care whom they happen to. You are just as likely a victim as the next fellow.

But, fortunately, there is something you can do about it. BE CAREFUL. Don't risk being a statistic on the daily casualty list.

The life you save may be your own.

MR. EMPLOYER:

Because both you and your employees have a stake in avoiding costly accidents The Advertising Council asks your cooperation in posting this vitally important message on your bulletin board.

THE ADVERTISING COUNCIL, INC.
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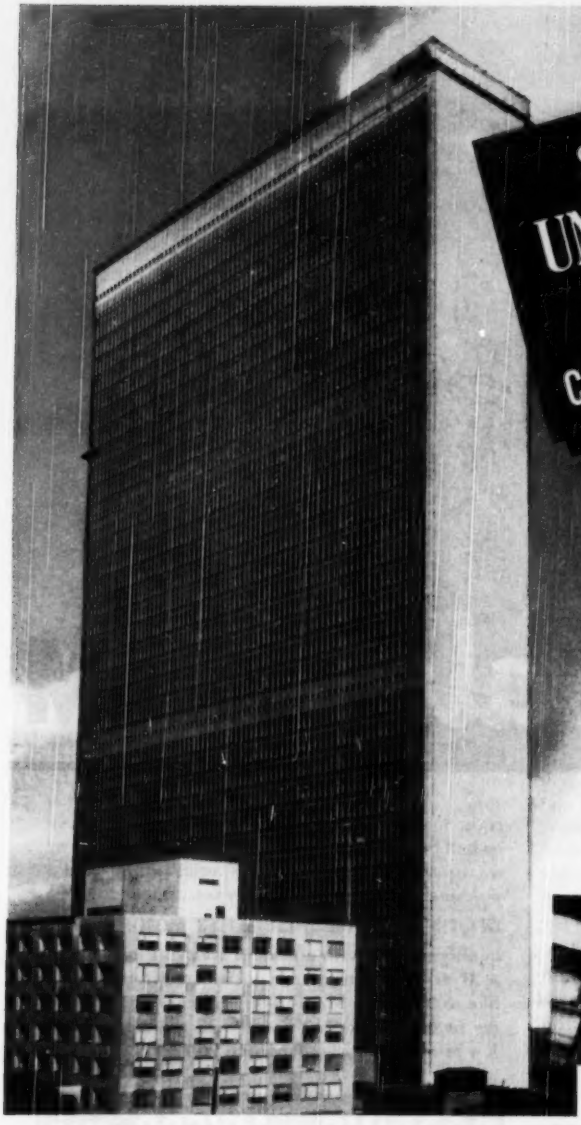
A non-profit organization representing all phases of advertising, dedicated to the use of advertising in public service.



Steam For Heating UNITED NATIONS BUILDINGS Controlled by Foster Valves

From the Metering Room in the Secretariat Building, steam from New York Steam Corp. is piped at 140 pounds to galleries on the sixth, sixteenth, and twenty sixth floors. Here it undergoes a two-stage reduction and is then distributed for heating service.

Other buildings in this group will also be served from the Metering Room, and steam pressures will be automatically regulated by Foster Valves.

Foster Representatives in principal cities will be glad to work with you on your regulating problems — without obligation.

For the first stage, Foster Type G single seated, internally piloted operated regulators reduce the pressure from 140 pounds to 50 pounds.

For the second stage, from 50 pounds to 5 pounds, Foster Type J-2 double seated, direct-acting, spring loaded diaphragm valves are used.

The UN Secretariat was designed by a board of architects from all over the world, with Wallace K. Harrison as Director of Planning, and is being built for the United Nations by Fuller-Turner-Walsh-Slattery, Inc. Syska & Hennessy were consulting mechanical engineers. Heating, ventilating and air conditioning systems installed by Almirall & Co., Inc.

FOSTER ENGINEERING Company

PRESSURE REGULATORS . . . RELIEF AND BACK PRESSURE VALVES . . . CUSHION CHECK VALVES . . . ALTITUDE VALVES . . . FAN ENGINE REGULATORS . . . PUMP GOVERNORS . . . TEMPERATURE REGULATORS . . . FLOAT AND LEVER BALANCED VALVES . . . NON-RETURN VALVES . . . VACUUM REGULATORS OR BREAKERS . . . STRAINERS . . . SIRENS SAFETY VALVES FLOW TUBES

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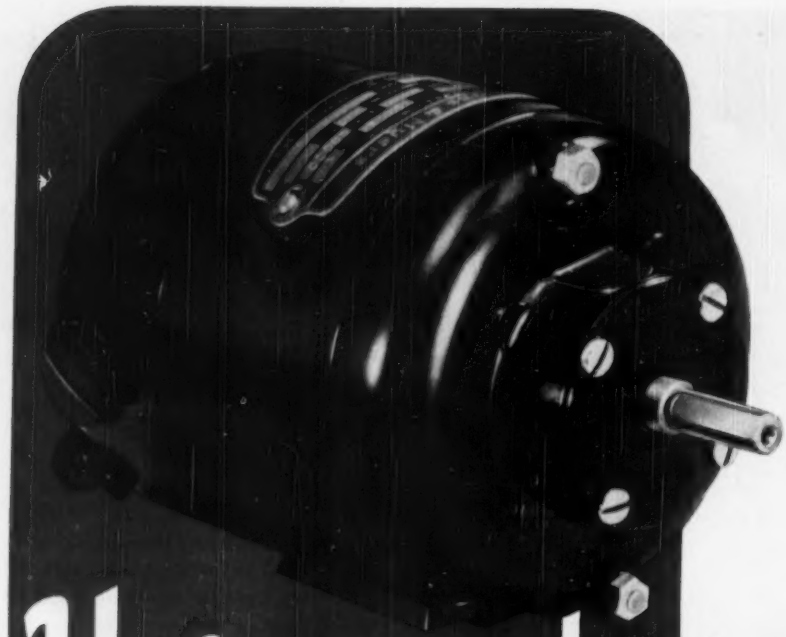

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● New R & M Universal Motors are something *you* should know about. To inherent *"series"* characteristics—high starting torque; high operating speed; adaptability to speed control—Robbins & Myers has added *many improvements* in performance and appearance.

BETTER, INSIDE AND OUT . . . From their dynamically balanced armatures to their rigid, welded-steel shells, *nothing* has been slighted. Commutation, brushes, bearings, insulation, and ventilation all represent progressive foresight, *backed* by long experience.

YOUR CHOICE . . In the range of 1/100 to ⅓ horsepower (covered by four frame sizes), there's the right motor for *every* "universal" service—sleeve or ball bearing; fixed rotation or reversible; open or totally enclosed; standard or special rating—and a *welcome variety* of housing types and end-heads.

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ROBBINS & MYERS, INC.
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Whether you want one worm-gear speed reducer or a thousand, a standard drive or a unit designed to meet special problems, Cleveland can serve you better.

Prompt service on dependable worm-gearing

● For dependable worm-gearing, consult Cleveland—a company which for 38 years has devoted its engineering skill and production facilities exclusively to the manufacture of high grade, precision-built worms and gears. Cleveland offers a complete line of worm gear sets and speed reducers, including the popular fan-cooled Speedaire—to meet the requirements of any machinery or equipment builder or user for this convenient, right-angle drive.

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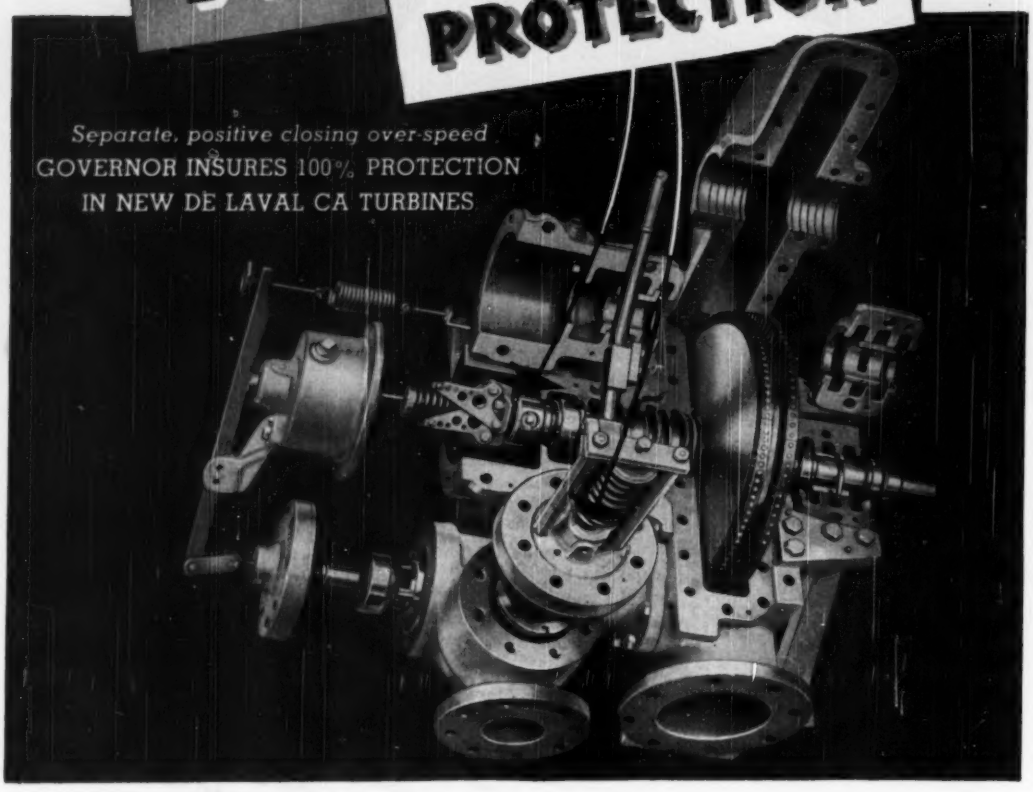
The Cleveland Worm & Gear Company, 3264 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

DOUBLE PROTECTION

Separate, positive closing over-speed
GOVERNOR INSURES 100% PROTECTION
IN NEW DE LAVAL CA TURBINES



The design of the new De Laval CA Turbine assures positive over-speed protection and unfailing emergency shut-off under any and all conditions.

In the CA Turbine, operation of the over-speed governor and emergency trip valve is in no way inter-dependent upon the operation of the normal speed governor or any other part of the turbine. A sticky governor valve cannot jeopardize its operation.

The functioning of the emergency trip valve is quick and sure. The stem of the valve rides freely without packing friction in a closely machined rust-resisting nickel-iron bushing. The valve closes against a single seat with the steam pressure acting on top of the valve to keep it tight. Foreign matter is kept away from the valve seat by a strainer in the steam line.

For double protection, specify the new De Laval CA Turbine.

DE LAVAL

Before you buy a turbine, be sure and get complete information on these additional De Laval features:

- ✓ True center line support and flexible mounting for perfect alignment.
- ✓ A choice of eight governors.
- ✓ Balanced double-seated bonnet-type governor valves for close control of steam flow.
- ✓ Sensitive, friction-free, wear-resistant "rocking chair" governor pivots. Super-smooth, chrome plated shaft journals make carbon rings last longer.
- ✓ The casing and bearings split horizontally at center line for easy removal and inspection of the rotor, carbon rings and bearings.

SEND FOR CATALOG 4202-22-A T-22

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TURBINES • HELICAL GEARS • CENTRIFUGAL BLOWERS AND COMPRESSORS • CENTRIFUGAL PUMPS • WORM GEAR SPEED REDUCERS • IMO OIL PUMPS

C-E REHEAT BOILERS

O. H. HUTCHINGS STATION

THE DAYTON POWER AND LIGHT COMPANY

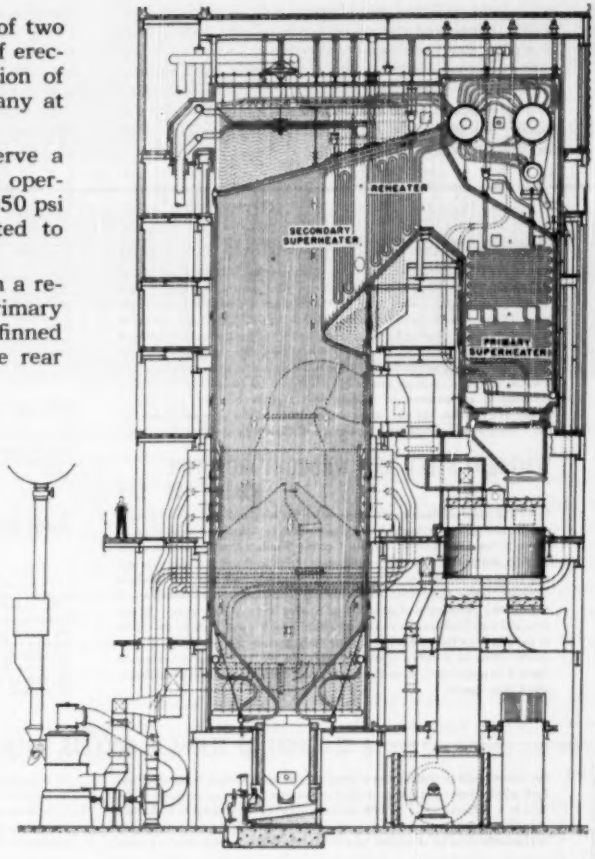
THE C-E Unit illustrated here, one of two duplicate units, is now in process of erection at the O. H. Hutchings Station of The Dayton Power and Light Company at Dayton, Ohio.

It is a reheat unit designed to serve a 60,000/66,000-kw turbine-generator operating at an initial steam pressure of 1450 psi at a temperature of 1000 F reheated to 1000 F.

The unit is of the radiant type with a reheater section located between the primary and secondary superheater surface. A finned tube economizer is located below the rear superheater section, and regenerative air heaters follow the economizer surface.

The furnace is fully water cooled, using closely spaced plain tubes except in the roof section, where finned tubes are employed. It is of the basket-bottom type, discharging to a sluicing hopper.

Pulverized coal firing is employed, using bowl mills and tilting tangential burners. B-406



C-E

COMBUSTION ENGINEERING—SUPERHEATER, INC.

200 Madison Avenue • New York 16, N. Y.

ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

Some up-to-date information on—

HIGH-TEMPERATURE PROPERTIES OF STEELS
HEAT CYCLE
TERMS IN NUCLEAR SCIENCE
PERFORMANCE-TESTING OF STEAM TURBINES
STANDARDS FOR INCORPORATION IN YOUR SPECIFICATIONS

STRENGTH OF WROUGHT STEELS AT ELEVATED TEMPERATURES

Those who need up-to-date information on the strength of properties of metals at elevated temperatures will welcome this recently published report because it shows graphically the tensile, creep, and rupture properties of: (1) plain carbon and alloy steels containing molybdenum and up to 3 per cent chromium, and (2) ferritic and austenitic steels containing more than 5 per cent chromium. The book also lists the 273 reference sources from which the information was obtained, the applicable ASTM specifications for each steel, and the ASTM standards referred to in the text.

Prepared by R. F. Miller and J. J. Heger for ASTM-ASME Joint Committee on the Effect of Temperature on the Properties of Metals, this 116-page Report is expected to go a long way to meet persistent and intensified requests from various sources. To designers of power equipment, chemical apparatus and machinery operating at elevated temperatures, it offers a fund of useful data.

By arrangement with the American Society of Testing Materials ASME members may purchase copies at $2.25; others will be charged $3.00.

SYMPOSIUM ON THE REHEAT CYCLE $1.50

This is a valuable collection of information on the following aspects of the reheat cycle: Performance and design of regenerative reheat steam turbines, particularly several large 1800-rpm tandem compound generating units; Gains in thermo efficiency as reflected in the turbine heat rate realizable in modern steam turbines for central stations; Turbines under construction for the resuperheated cycle; History of the reheat cycle, its advantages, and present and future possibilities; Technical and operating problems connected with the selection of steam generating equipment for resuperheating cycles; Application of reheaters to modern high pressure boilers; and Design factors which dictate the size, shape and proportions of a large reheat generator. Sixteen pages of discussion conclude the Symposium. Published 1949

WROUGHT-STEEL AND WROUGHT-IRON PIPE B36.10—1950 $.65

This 1950 Standard conforms to usage which has followed pipe made to commercial dimensions instead of those equivalent to Scheduled Wall Pipe as shown in the 1939 Edition. Table 1 of the Standard lists the specifications for pipe, their titles, and ASA designation. Tables 2 and 3 give the weight and thickness dimensions of welded and seamless steel pipe by schedule numbers; Tables 4 and 5 list the commercial dimensions, while Tables 6 and 7 provide the commercial dimensions of welded wrought iron pipe. Where sizes and wall thickness are common to both Tables 2 and 4, these are shown in bold face in the footnotes of each table thereby permitting the user to specify either by schedule number in Table 2 or by the caption of columns in Table 4 (standard wall, extra strong wall, and double extra strong wall) under which they appear.

STEAM TURBINE TEST CODE $2.00

Formulated by the ASME Committee on Power Test Codes, this book provides complete test recommendations and detailed information for all types of steam turbines including reheating, regenerative, extraction and mixed pressure turbines. Instructions are given for making the necessary temperatures and flow measurements, calculating and reporting results, and on making corrections to test performance. A check list of items on which agreement should be reached before acceptance is included. Published 1949

STEAM TURBINE TEST CODE APPENDIX $2.00

This Section will be found invaluable when working up test reports, particularly the numerical examples of many of the calculations that are involved in a report of a test of a steam turbine carried out under the code rules. Published 1949

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Terms used in *Chemical Engineering* and in *Biophysics and Radiobiology* are now available. The others are expected to be ready for publication sometime between July and December 1950.

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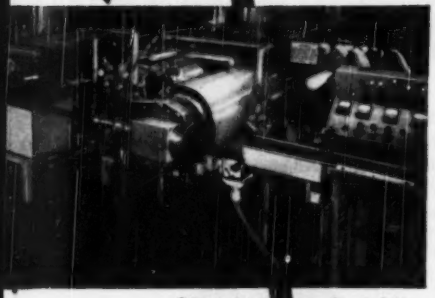

Oilgear drives [illegible] synchronized to speed of Royle [illegible]der which covers cable with mel[illegible]olyethylene.

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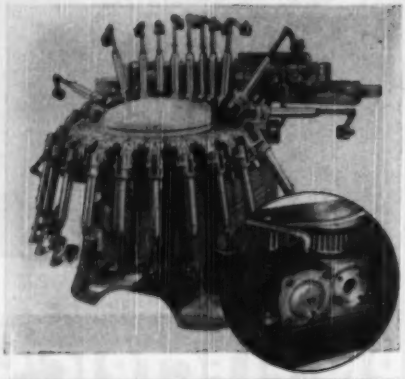

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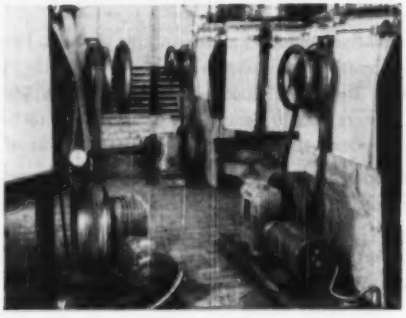

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When Winona Knitting Mills motorized its rotary knitting machines individually, they picked Cone-Drive reducers for this 24-hour-a-day, 6-days-a-week service. Each of the units handles 1½ hp at 1150 rpm.

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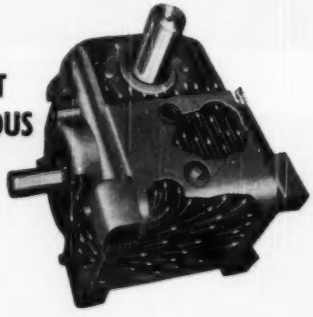

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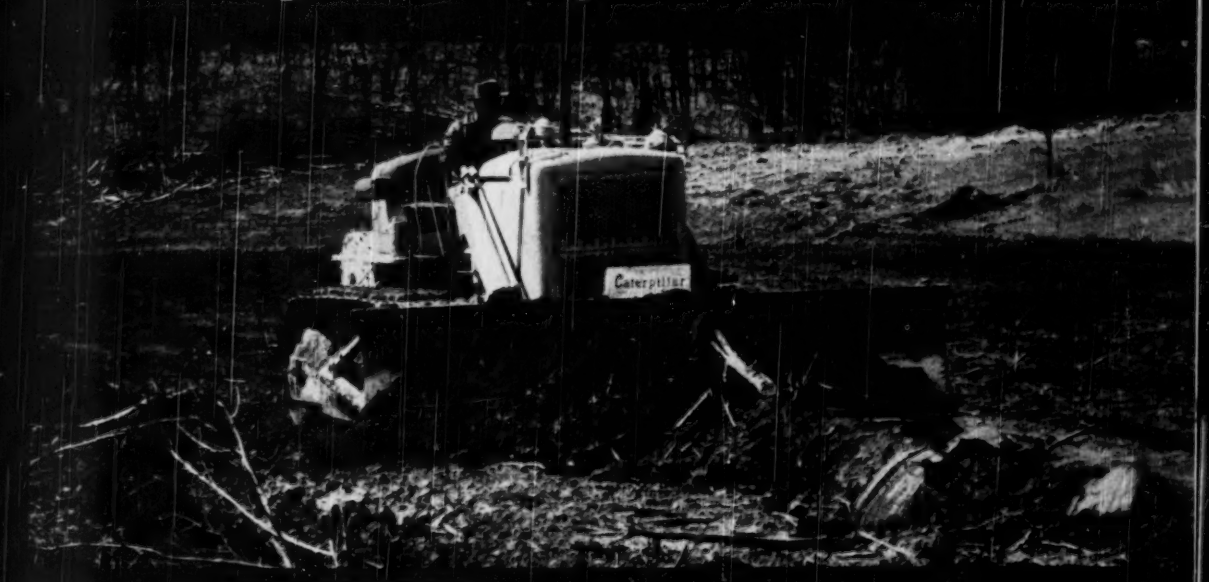

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3984

VICKERS
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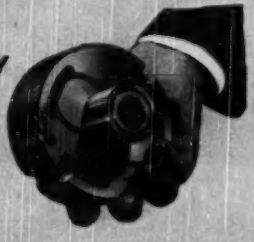
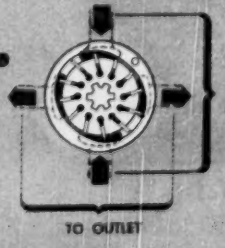


This cartridge contains all the pumping parts that move . . . none of them contact the housing. Inspection and removal of all working parts can be made without disconnecting piping or drive coupling.

VICKERS
Hydraulic Balance



With this patented construction, bearing loads are cancelled out by equal and opposing radial hydraulic thrust loads as shown in diagram. The result is longer pump life with minimum maintenance.

The cylindrical body defies distortion

LUNKENHEIMER FIG. 2228 LINE UNION BONNET GATE VALVES

In this design of 200 lb. S. P. Bronze Union Bonnet Gate Valves, Lunkenheimer incorporates the first application of full cylindrical body sections in bronze gate valves. This construction, previously used only in higher pressure steel valves, provides great strength and maximum resistance against distortion of the valve body and seats due to internal pressure strains and other stresses. Tests made under conditions far more severe than those encountered in actual service prove that this design will not distort and will maintain initial proportions and seat tightness.

In addition to the cylindrical body construction and other service-giving features, the valves are equipped with stems made of the distinctive silicon bronze alloy developed by Lunkenheimer to eliminate stem-thread failure due to wear.

Union Bonnet Rising Stem Fig. 2228 Screwed

Union Bonnet Non-Rising stem Fig. 2230 Screwed

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O. S. & Y. Union Bonnet Rising stem Fig. 2232 Screwed

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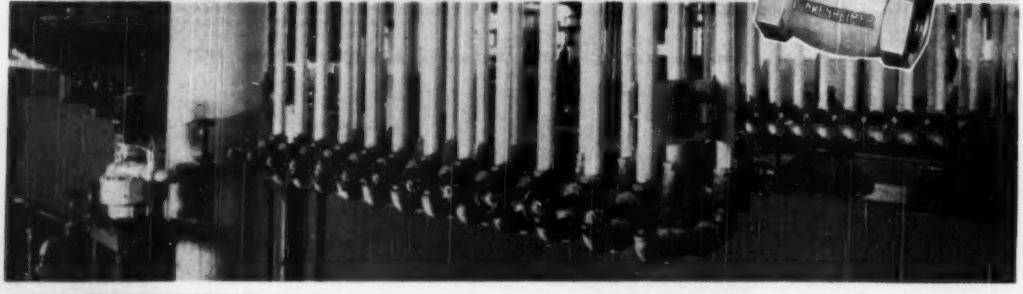

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CORROSION RESISTANCE
GENERAL ELECTRIC
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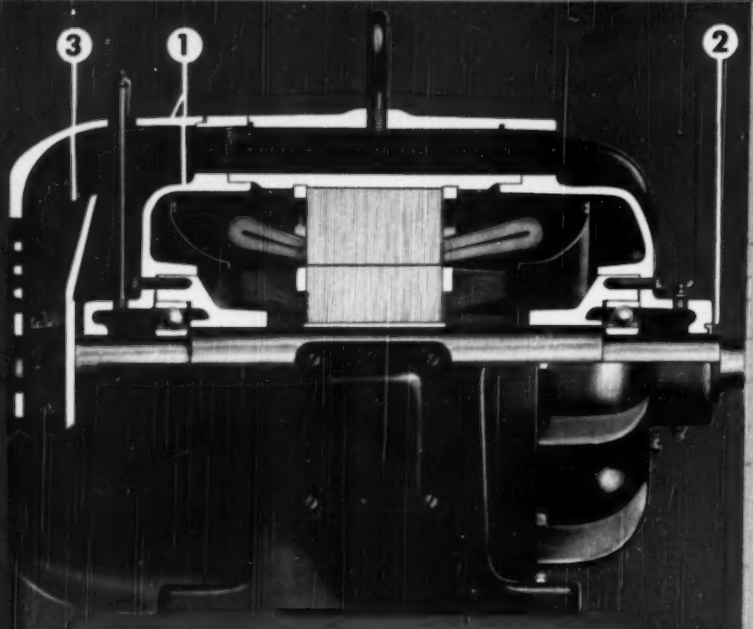
Why



Here's the totally enclosed Tri-Clad double-shell structure (1) that locks out dirt, flying metal chips, abrasive dust and corrosive fumes. Check the rotating labyrinth seal (2) which prevents foreign matter from working in along the shaft. Note the cast-iron housing, the corrosion-resistant G-E Textolite* material cooling fan (3). Fan circulates cooling air between the shells—no contaminated air touches the punchings or inside parts.

You can't beat TRI/CLAD motors for corrosion resistance

Acid fumes, alkali dust, dye-house vapors, tropical weather — you name *your* motor "poison." You just can't beat Tri-Clad cast-iron construction for corrosion resistance.

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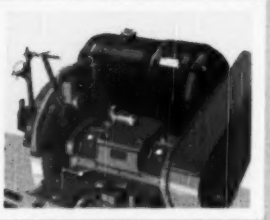
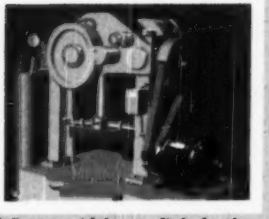
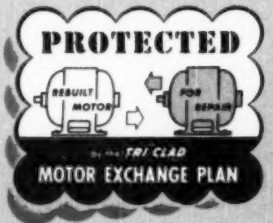


G-E Type ACA induction motors for adjustable speeds—provide speed ranges from 3-1 to 20-1. From 3 to 75 hp.

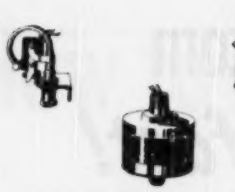


G-E open (dripproof) induction motors for constant-load, constant-speed applications. From 1 to 2000 hp.

G-E totally enclosed motors for outdoor operation, in abrasive dusts, or corrosive fumes. From 1 to 1000 hp.



Look for this **EXTRA** on the motor you buy!



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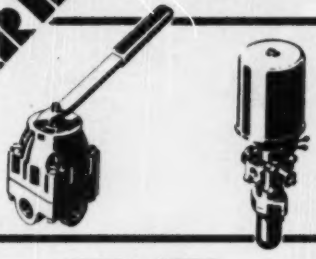

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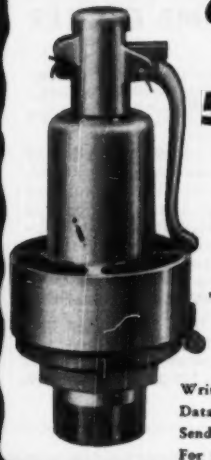

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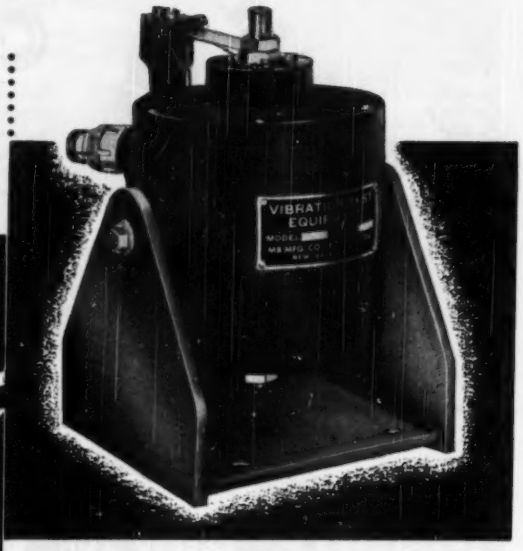

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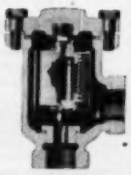

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Process Tanks, large	B	C
Dryers, Coil Type	B	A
Dryers, Fan Type	B	C
Drying Tumblers	B	A
Water Heaters	B	C
Preheaters, Fuel Oil	B	C
Rotating Cylinders	B	B
Slashers	B	B
Dry Cans	B	B
Flat Work Ironers	C	B
Presses, Laundry	C	A
Stocking Forms	C	A
Presses, Plastics	C	A
Presses, Platen	C	A
Evaporators	B	C
Steam Lines Outdoors, small	A	D

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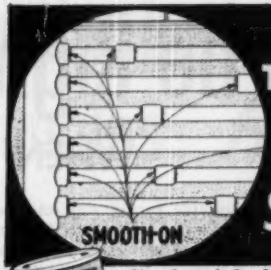

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MECHANICAL ENGINEERING
June, 1950 CARD INDEX Vol. 72, No. 6

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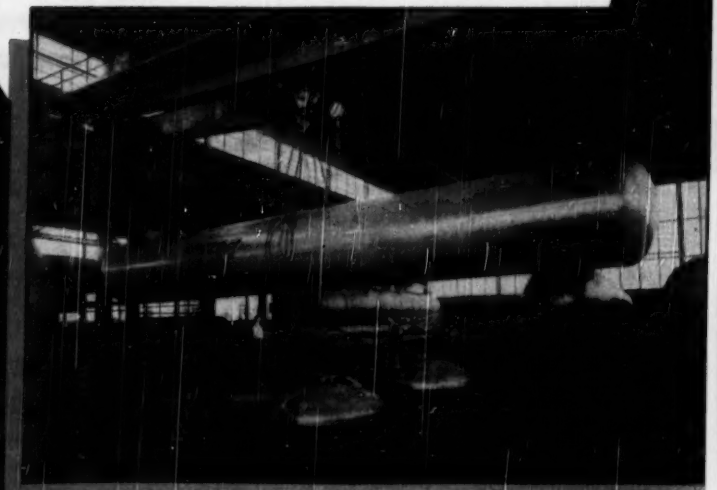

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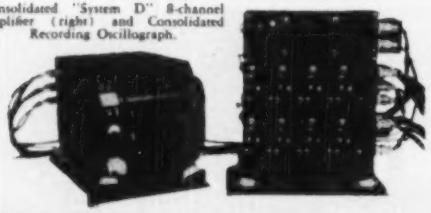
Consolidated "System D" 8-channel amplifier (right) and Consolidated Recording Oscillograph.



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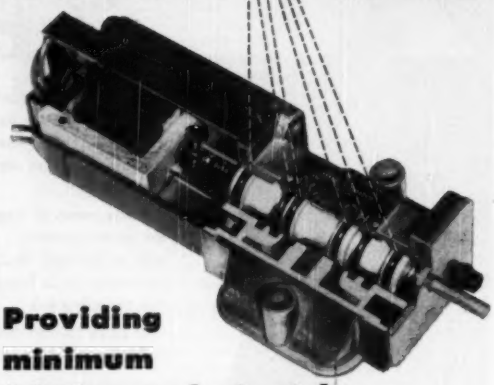

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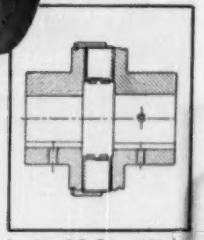

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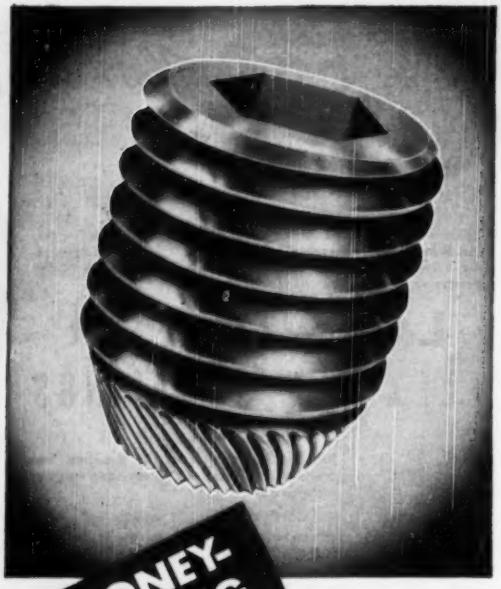

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Continued on Page 96

Two Pages of "OPPORTUNITIES" This Month . . . 95-96

POSITIONS WANTED

Continued from Page 95

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through moving pipe lines

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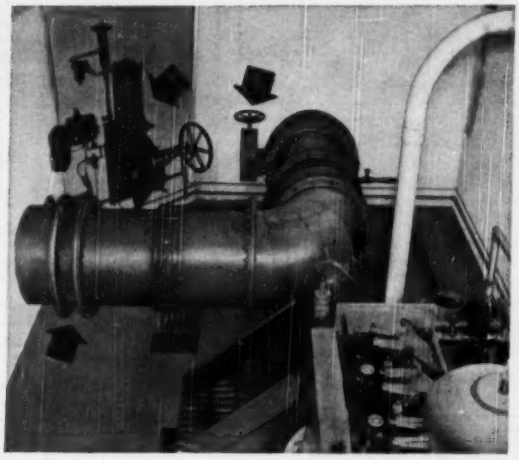

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Consult with your local R-S Valve Engineers. Look for the address and phone number listed under "R-S Products, Valves" or write direct.

R-S PRODUCTS CORPORATION
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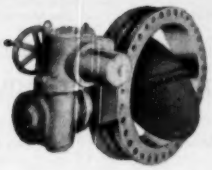
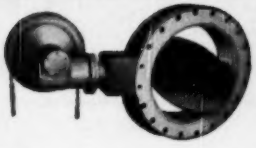
No. 700—20-inch 50-pound Cast Iron Valve with rubber seat, Type B-8934, for positive 100% shut-off. Heavy duty handwheel control with threaded reach rod. Type B-9469.



No. 724—42-inch 50-pound Heavy Service Valve, B-9813, complete with limitorque motor and gear reduction drive No. 4. Angular seating vane for wedge-type closure with metal seat. Rubber seat available if desired. Valve body good for 125 psi gauge static head and drip tight shut-off at 50 psi pressure drop with rubber seat.

No. 768—66-inch Fabricated Steel Handwheel Operated Valve with ends scrafled for welding. 6½-inch diameter one piece Stainless Steel shaft mounted on thrust bearings (valve installed with shaft vertical). Horizontal and vertical ribs on body prevent distortion when machining and assembling. Stuffing box easily repacked. Used to control river flow during dam construction. Open atmospheric discharge.



No. 737—20-inch 50-pound Heavy Service Valve (B9804) with rubber seat (B8934). Gear reduction drive No. 3 with chainwheel.

RATES One Inch Card Announcements inserted at rate of $15.00 per issue, $12.00 per issue on yearly contract.

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Manufacturers of Equipment Not Included

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Registered Patent Attorneys
Patent Practice before U. S. Patent Office, Validity and Infringement Investigations and Opinions. Booklet and form "Evidence of Conception" forwarded upon request.
Suite 479, 815-15th St., N.W., Washington 5, D. C.

Consult **Z. H. POLACHEK**
Reg. Patent Attorney
1234 Broadway
(at 31st St.) New York 1, N. Y.
Phone LO 5-3088

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Spring Design Specialists
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Industrial Power—Surveys & Design
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Qualitative and Quantitative Since 1936
Micro and Semimicro analyses of metallics; conventional and metallurgical analyses, metallography, metal failures investigated, heat treating consultants, photomicrographs, Jominy Hardenability, physical tests.
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Inspection—Research
NATIONAL WELD TESTING BUREAU
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Project Engineering, Product Development, Production Designs, Laboratory and Shop Facilities for Research, Model Work, and Pilot Manufacturing
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An announcement in this section will acquaint others with your specialized practice.

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INDUSTRIAL ENGINEER
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GEORGE H. KENDALL
Consulting Mechanical Engineer
Cost Reduction Studies: Process or Product.
Redesign Existing Products for Greater Profit.
Trouble Shooting Production, Design, Cost Problems.
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P. O. Box 72 — (Est. 1923) — Tel. Darien 5-1504
Noroton Heights — Darien, Connecticut

DESIGNING ENGINEERING
Machines • Products • Plants
Processes • Production • X-Ray
SAM TOUR & CO., INC.
44 TRINITY PL., N. Y. 6, N. Y.

The above consultants are available
to work out solutions
to your engineering and management problems.

The look that keeps telephone costs DOWN

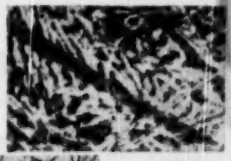
Examining specimen on metallographic microscope at Bell Telephone Laboratories.

Through his microscope this Bell metallurgist examines a bit of material which is proposed for telephone use. From what he sees of grain structure, he gains insight into performance not provided by spectrum or chemical analysis. He learns how to make telephone parts stand up longer, so that telephone costs can be kept as low as possible.

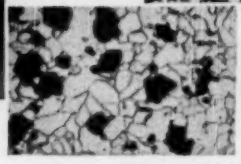
The items which come under scrutiny are many and varied, ranging from manhole covers to hair-thin wires for coils, from linemen's safety buckles to the precious metal on relay contacts.

In joints and connections—soldered or welded, brazed or riveted – photomicrographs reveal flaws which would escape ordinary tests. They show if a batch of steel has the right structure to stand up in service; why a guy wire let go in a high wind or a filament snapped in a vacuum tube; how to make switchboard plugs last longer.

In their exploration of micro-structure, Bell Telephone Laboratories scientists have contributed importantly to the metallographic art. You enjoy the benefits of their thoroughgoing testing and checking in the value and reliability of your telephone system, and the low cost of its service.



Photomicrograph of white cast iron which is hard and brittle.



Same iron rendered malleable by heat treatment. Shows spots of nodular carbon.

BELL TELEPHONE LABORATORIES

WORKING CONTINUALLY TO KEEP YOUR TELEPHONE SERVICE BIG IN VALUE AND LOW IN COST

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*Zurn, J. A., Mfg. Co.

MECHANICAL ENGINEERING, 29 W. 39th St., New York 18, N. Y.

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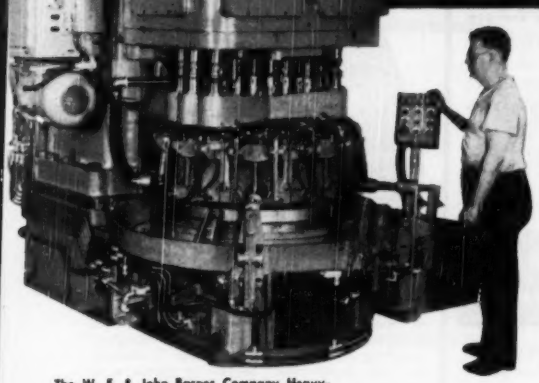
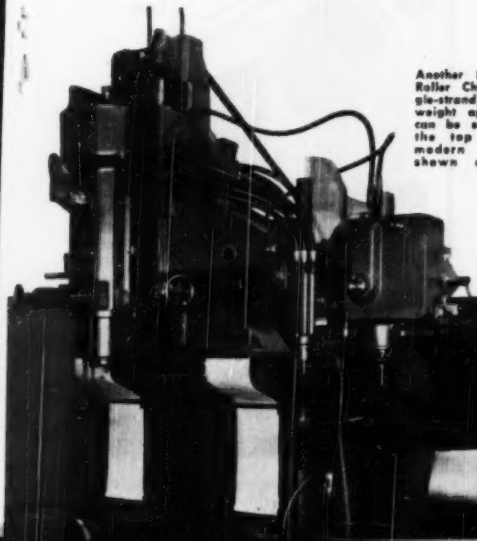
FOR GREATEST SAFETY IN COUNTERWEIGHT SERVICE



The W. F. & John Barnes Company Heavy-Duty Vertical Machine employs Diamond triple Roller Chain in counterweight service.



Another Diamond Roller Chain (single-strand) counterweight application can be seen near the top of the modern machine shown at left.

DIAMOND Roller Chains

• For counterweight service, where the ultimate in safety for operator and machine is so essential,—the reliability of Diamond Roller Chains has long been recognized by machine tool builders and users.

Joint articulation is sustained by diameter-ground case hardened alloy steel pins in case hardened alloy steel bushings. The pins are press-fit in pin link plates;—the bushings, in roller link plates preventing relative motion of link plates and the round parts.

Strength and durability are maintained, — elongation minimized — accuracy and positive operation assured. For the ultimate in safety, Diamond Roller Chains should be your choice, too.

DIAMOND CHAIN COMPANY, Inc., Dept. 413, 402 Kentucky Avenue, Indianapolis 7, Indiana.

Offices and Distributors in all principal cities.

Refer to the classified section of your local telephone directory under the heading CHAINS or CHAINS-ROLLER.

One HEAVY-DUTY CLARAGE Unit for:

A- Controlling Temperature
B- Controlling Humidity
C- Insuring Air Cleanliness

Use Clarage Capillary Air Conditioners where *maximum air cleanliness plus accurate control of temperature and humidity* are vital to production, uniformity of product, health or safety.

These Capillary Conditioners are completely assembled units, including a capillary cleaning section, pump, heating coils, fans, drive and motor. Built in seven sizes — 1,800 to 20,000 cubic feet of air per minute, either vertical or horizontal units.

There are excellent reasons for preferring this modern equipment: (1) *Inexpensive to install* — no costly building alterations required; (2) *Everything in one "package"* — no parts to assemble; (3) *Proper performance* assured by factory tests; (4) *Low first and operating costs* — the result of shrewd, advanced engineering.

CAPILLARY AIR WASHERS
4,400 to 132,000 CFM

Clarage Capillary Air Washers are widely used where you need air cleanliness only (temperature and humidity control not desired), or they may serve as the cleaning units in complete air conditioning central systems. Built in 5 height and 11 width sizes.

All Clarage equipment is HEAVY-DUTY; *fully equal to severest industrial requirements.*

We Also Make: Complete Line of Industrial Fans . . . Unit Heaters . . . Air Conditioning Equipment . . . Mechanical Draft Apparatus

CLARAGE FAN COMPANY — *Kalamazoo, Michigan*

CLARAGE
—HEADQUARTERS for Air Handling and Conditioning Equipment

SEE OUR CATALOG IN SWEET'S

It pays to direct fan inquiries our way . . . phone Clarage office in your city, or write us at Kalamazoo.

Application Engineering Offices in All Principal Cities

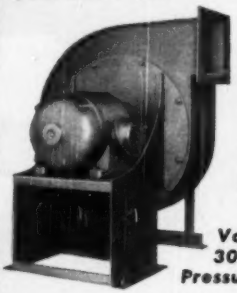
Capacities to 4000 CFM

Pressures to 20"

THREE Economy Answers to Industrial Air Handling Problems

1

TYPE CI EXHAUSTERS are built to the *same exacting standards* as the largest Clarage equipment; *heavy-duty* in every sense of the word! Widely used for removing excess heat, smoke, odors from manufacturing operations . . . in pneumatic conveying . . . supplying air to oil burners, as over-fire fans, etc. Regularly furnished with corrosion-resisting cast iron housings, or in any special construction your special needs demand.



2

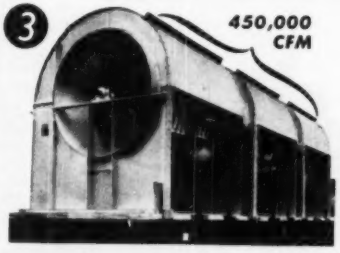
Type O Blowers

Volumes to 30,000 CFM
Pressures to 35"

For *higher pressure*, larger capacity applications . . . supplying air to cupolas, industrial gas and oil burners, etc. Fan housings and wheels of heavy steel plate "take in stride" toughest operating conditions. Clarage Type O blowers are built in 19 sizes; operate at speeds *most economical* for direct motor or turbine drive.

3

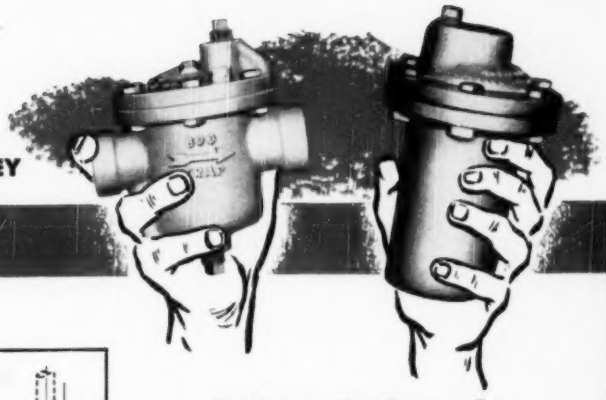
450,000 CFM

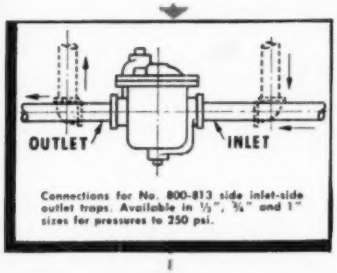


CLARAGE BUILDS equipment *big enough for ANY air handling requirement.* Example: these three Type W Fans recently shipped to a steel plant, and now installed in a large building where gas engines generate electricity. They dilute escaping toxic gas fumes, thus providing safe air for workers. Each fan delivers 150,000 cubic feet of air per minute; must operate continuously. Their *heavy-duty* qualities insure uninterrupted service on this essential job.

CLARAGE FAN COMPANY, Kalamazoo, Mich.

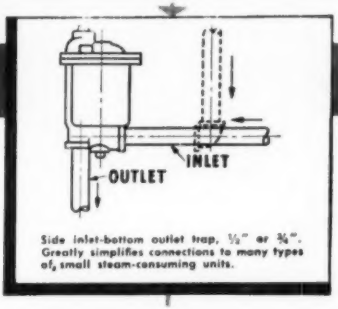
YOU SAVE
TIME AND MONEY



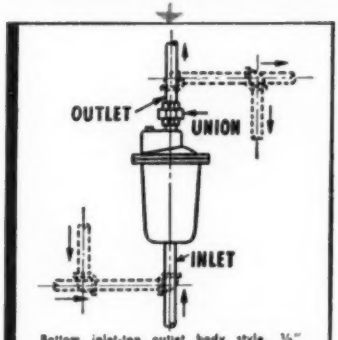


Connections for No. 800-813 side inlet-side outlet traps. Available in ⅛", ¼" and 1" sizes for pressures to 250 psi.

"This choice of Steam Trap Body Styles simplifies installations"



Side inlet-bottom outlet trap. ⅛" or ¼". Greatly simplifies connections to many types of small steam-consuming units.



Bottom inlet-top outlet body style. ⅛" through 2" connections. Cast semi-steel bodies for pressures to 250 psi. Forged steel bodies for pressures to 1500 psi.

IN THE most widely used sizes, Armstrong Steam Traps are available in either side inlet-side outlet or bottom inlet-top outlet body styles. This gives the user an opportunity to make exceptionally neat installations with a minimum of fittings and a minimum of labor and permits correct location of the trap in relation to the unit being drained.

In both styles the entire interior mechanism may be taken out for inspection or repair simply by removing the cap. The body, full of boiling water, is left in the line. In the case of the side inlet trap the cap may be removed without even disturbing the pipe connections.

Ask your nearby Armstrong representative to show you the opportunities for simplifying trap installations.

ARMSTRONG MACHINE WORKS
894 Maple St., Three Rivers, Mich.

THE 36-PAGE ARMSTRONG STEAM TRAP BOOK gives data and prices on the complete line of Armstrong steam traps for every pressure, every application. This book is a valuable reference for the calculation of condensate loads and the selection of traps for all classes of equipment. Send for free copy today

ARMSTRONG STEAM TRAPS

Rigid rule for spindles– TIMKEN® bearings

YOU get the kind of spindle rigidity you want for extreme, lasting precision by mounting the spindle on Timken® tapered roller bearings. That's why most machine tool manufacturers make it a rule to use Timken bearings.

The new Giddings and Lewis 300 horizontal boring, drilling and milling machine shown below is a good example. Timken bearings keep its 3" diameter spindle in positive alignment, minimize deflection and end-movement.

Their tapered construction takes loads from any direction and permits accurate preloading to any degree wanted. Their line contact between rollers and races provides extra load-carrying capacity. Their true rolling motion and extremely smooth surface finish practically eliminate friction. And because Timken bearings are engineered for the job, made of tough, wear-resistant Timken alloy steel, and precision-manufactured, they normally last for the life of the machine.

Make sure your machine tools have the fine, long-term accuracy that only Timken bearings can give. Use only bearings that bear the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

Here's how **GIDDINGS & LEWIS TOOL COMPANY** *uses Timken bearings on spindle of this machine. Result: extreme, long-lasting precision.*

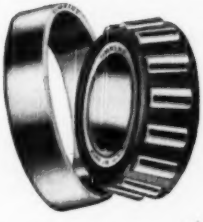
FINISHED TO CLOSER TOLERANCES

Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods at Timken.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ◫ AND THRUST ⊣◫ LOADS OR ANY COMBINATION ⊣◫